CIVIL ENGINEERING COLLEGE,

SIBPUR.

CALENDAR FOR 1897.

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CIVIL ENGINEERING COLLEGE, SIBPUR, CALENDAR.

ALMANAC, 1897.

JANUARY 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	F.			
2	S.	Christmas vacation ends		
3	Sun.	2nd Sunday after Xmas.		
4	M.			
5	T.			
6	W.			
7	Th.			
8	F.			
9	S.			
10	Sun.	1st Sunday after Epiphany.		
11	M.			
12	T.			
13	W.			
14	Th.			
15	F.	Monthly fees due.		
16	S.			
17	Sun.	2nd Sunday after Epiphany.		
18	M.			
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	3rd Sunday after Epiphany.		
25	M.	Monthly statement of fees due.		
26	T.			
27	W.			Practical examination of 3rd-year apprentices begins.
28	Th.			
29	F.			
30	S.		Students return from Survey Camp.	
31	Sun.	4th Sunday after Epiphany.		

FEBRUARY 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			New students join.
2	T.			
3	W.			
4	Th.			
5	F.			
6	S.	Sri Panchami—College holiday.		
7	Sun.	5th Sunday after Epiphany.		
8	M.			
9	T.			
10	W.	College sports.		
11	Th.			
12	F.			
13	S.			
14	Sun.	Septuagesima.		
15	M.	Monthly fees due		
16	T.			
17	W.			
18	Th.			
19	F.			
20	S.			
21	Sun.	Sexagesima.		
22	M.			
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.			
27	S.			
28	Sun.	Quinquagesima.		

MARCH 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			Monthly examination begins.
2	T.			
3	W.	Ash Wednesday.		
4	T			
5	F.	Id-ul-fitr (one day).		
6	S.			
7	Sun.	1st Sunday in Lent.		
8	M.			
9	T.			
10	W.			
11	Th.			
12	F.			
13	S.		3rd year drawings to be sent into office.	
14	Sun.	2nd Sunday in Lent.		
15	M.	Monthly fees due.		
16	T.			
17	W.			
18	Th.	Dol Jatra—College holiday.		
19	F.			
20	S.			
21	Sun.	3rd Sunday in Lent.		
22	M.		Last day for receiving applications for F.E. Examination.	
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.			
27	S.			
28	Sun.	4th Sunday in Lent.		
29	M.			
30	T.			
31	W.			

APRIL 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.	Advertise Accountant Examination in *India Gazette.*		
4	Sun.	5th Sunday in Lent.		
5	M.			Monthly examination begins.
6	T.			
7	W.	Advertise Accountant Examination in *Calcutta Gazette.*		
8	Th.			
9	F.			
10	S.			
11	Sun.	6th Sunday in Lent.		
12	M.	Chaitra Sankranti—College holiday.		
13	T.			
14	W.	Detailed statement of establishment due.		
15	Th.	Monthly fees due.		
16	F.	Good Friday.		
17	S.	Advertise admission to Engineer Department in *India Gazette.*		
18	Sun.	Easter Day.		
19	M.		F. E. Examination begins.	
20	T.			
21	W.	Advertise admission to Engineer Department in *Calcutta Gazette.*		
22	Th.			
23	F.			
24	S.			
25	Sun.	1st Sunday after Easter.		
26	M.	Monthly statement of fees due.		
27	T.			
28	W.			
29	Th.			
30	F.	Indent for chemical apparatus due.		

MAY 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	S.	Report of Surveying instruments for repair due.		
2	Sun.	2nd Sunday after Easter		
3	M.			Monthly examination begins.
4	T.			
5	W.		Practical examination, 1st and 2nd years, begins.	
6	Th.			
7	F.			
8	S.			
9	Sun.	3rd Sunday after Easter.		
10	M.			
11	T.			
12	W.			
13	Th.			
14	F.	Id-uz-zuha (one day).		
15	S.	Monthly fees due.	Last day for receiving applications for admission.	
16	Sun.	4th Sunday after Easter.		
17	M.			
18	T.			
19	W.			
20	Th.			
21	F.			
22	S.			
23	Sun.	5th Sunday after Easter.		
24	M.	Queen's Birthday.		
25	T.	Monthly statement of fees due.	Annual examination, 1st and 2nd years, begins.	
26	W.			
27	Th.	Ascension Day.		
28	F.			
29	S.		Project drawings and calculations to be sent into office.	
30	Sun.	Sunday after Ascension.		
31	M.	Indent for stationery due.		

JUNE 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.			
2	W.			Monthly examination begins.
3	Th.			
4	F.			
5	S.			
6	Sun.	Whitsunday.		
7	M.	4th grade Accountant Examination begins.	Opening of session. New students join.	
8	T.			
9	W.			
10	Th.	Dasahara—College holiday.		
11	F.	Muharram (two days).		
12	S.			
13	Sun.	Trinity Sunday.		
14	M.		Last days for receiving applications for L.E. and B.E. Examinations.	
15	T.	Monthly fees due.		
16	W.			
17	Th.			
18	F.			
19	S.			
20	Sun.	1st Sunday after Trinity.		
21	M.			
22	T.			
23	W.			
24	Th.			
25	F.	Monthly statement of fees due.		
26	S.	Indent for forms due.		
27	Sun.	2nd Sunday after Trinity.		
28	M.		L.E. and B.E. Examinations begin	
29	T.			
30	W.			

JULY 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			Monthly examination begins.
2	F.			
3	S.			
4	Sun.	3rd Sunday after Trinity		
5	M.			
6	T.			
7	W.			Final examination, 4th year, begins.
8	Th.			
9	F.			
10	S.			
11	Sun.	4th Sunday after Trinity.		
12	M.			Practical examination, 1st, 2nd, and 3rd years, begins.
13	T.			
14	W.			
15	Th.	Monthly fees due		
16	F.			
17	S.			
18	Sun.	5th Sunday after Trinity.		
19	M.			
20	T.			
21	W.			Practical examination, 4th year, begins.
22	Th.			
23	F.			
24	S.			
25	Sun.	6th Sunday after Trinity.		
26	M.	Monthly statement of fees due.		Annual examination, 1st, 2nd, and 3rd years, begins.
27	T.			
28	W.			
29	Th.			
30	F.			
31	S.	Budget estimate due.		

AUGUST 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Sun.	7th Sunday after Trinity.		
2	M.			
3	T.			
4	W.			
5	Th.			
6	F.			
7	S.			
8	Sun.	8th Sunday after Trinity.		
9	M.			
10	T.			
11	W.	Fatiha Dawazdaham (one day).		
12	Th.	Monthly fees for August and September due.		
13	F.	Long vacation begins.		
14	S.			
15	Sun.	9th Sunday after Trinity.		
16	M.			
17	T.			
18	W.			
19	Th.			
20	F.	Janmashtami.		
21	S.			
22	Sun.	10th Sunday after Trinity.		
23	M.			
24	T.			
25	W.	Monthly statement of fees due.		
26	Th.			
27	F.			
28	S.			
29	Sun.	11th Sunday after Trinity.		
30	M.			
31	T.			

SEPTEMBER 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.			
2	Th.			
3	F.			
4	S.			
5	Sun.	12th Sunday after Trinity.		
6	M.			
7	T.			
8	W.			
9	Th.			
10	F.			
11	S.			
12	Sun.	13th Sunday after Trinity		
13	M.			
14	T.			
15	W.			
16	Th.			
17	F.			
18	S.			
19	Sun.	14th Sunday after Trinity.		
20	M.			
21	T.			
22	W.			
23	Th.			
24	F.			
25	S.	Monthly statement of fees due.		
26	Sun.	15th Sunday after Trinity.		
27	M.			
28	T.			
29	W.			
30	Th.	Durga Puja.		

OCTOBER 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	F.			
2	S.			
3	Sun.	16th Sunday after Trinity.		
4	M.			
5	T.			
6	W.	Durga Puja.		
7	Th.			
8	F.			
9	S.			
10	Sun.	17th Sunday after Trinity.		
11	M.			
12	T.			
13	W.			
14	Th.			
15	F.			
16	S.			
17	Sun.	18th Sunday after Trinity.		
18	M.			
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	19th Sunday after Trinity.		
25	M.	Kali Puja.		
26	T.			
27	W.	Monthly statement of fees due.		
28	Th.			
29	F.			
30	S.			
31	Sun.	20th Sunday after Trinity.		

NOVEMBER 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			
2	T.			
3	W.	Jagadhatri Puja.		
4	Th.	Jagadhatri Puja.		
5	F.			
6	S.	Long vacation ends.		
7	Sun.	21st Sunday after Trinity.		
8	M.			
9	T.			
10	W.		Examination of 1st, 2nd, and 3rd years in vacation work.	
11	Th.		1st year Surveying begins.	
12	F.			
13	S.			
14	Sun.	22nd Sunday after Trinity.		
15	M.	Monthly fees due.	2nd year Surveying begins.	2nd, 3rd, and 4th years Surveying begins.
16	T.			
17	W.	Advertise admission to Apprentice Department in *Calcutta Gazette*.		
18	Th.			
19	F.			
20	S.	Advertise admission to Apprentice Department in *India Gazette*.		
21	Sun.	23rd Sunday after Trinity.		
22	M.		3rd year Surveying begins.	
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.			
27	S.			
28	Sun.	1st Sunday in Advent.		
29	M.			
30	T.			

DECEMBER 1897.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.			
2	Th.			
3	F.			
4	S.			
5	Sun.	2nd Sunday in Advent.		
6	M.			
7	T.			
8	W.		Annual tour of senior students begins.	
9	Th.			
10	F.			
11	S.			
12	Sun.	3rd Sunday in Advent.		
13	M.			
14	T.			
15	W.	Monthly fees due.		
16	Th.			
17	F.			
18	S.			
19	Sun.	4th Sunday in Advent.		
20	M.			
21	T.			
22	W.	Xmas holidays begin.		
23.	Th.			
24	F.			
25	S.	Xmas Day.		
26	Sun.	1st Sunday after Christmas.		
27	M.			
28	Tu.	Monthly statement of fees due.		
29	W.			
30	Th.			
31.	F.			

CIVIL ENGINEERING COLLEGE, SIBPUR.

BOARD OF VISITORS.

1. Secretary to the Government of Bengal, Public Works Department.
2. Director of Public Instruction, Bengal.
3. Secretary to the Government of Bengal, Irrigation and Marine Departments.
4. Civil Surgeon, Howrah. } *Ex-officio.*
5. Inspector of Schools, Presidency Circle.
6. Principal, Civil Engineering College, Sibpur.
7. Executive Engineer, Calcutta Workshops Division.
8. Magistrate of Howrah.
9. Superintendent of Works, Calcutta.
10. W. H. Ryland, Esq.
11. Mahamahopadhyaya Mahes Chandra Nyaratna, C.I.E.
12. The Lord Bishop of Calcutta.
13. Maharajah Sir Jotendra Mohan Tagore Bahadur, K.C.S.I.
14. Brigade-Surgeon G. King, M.D., LL.D., F.R.S., C.I.E.
15. F. J. E. Spring, Esq.
16. A. Macdonell, Esq., Secretary.

COLLEGE STAFF.

Principal and Professor of Engineering ... J. S. Slater.

Engineer Department.

Professor of Mathematics	A. Macdonell.
Officiating Professor of Surveying ...	B. Heaton.
Professor of Chemistry and Drawing ...	William Tate, A.R.C.S., F.C.S.
Ditto Physical Science ...	P. J. Brühl.
Assistant to Professor of Drawing ...	Surendra Kumar Base, B.C.E.
Ditto ditto Chemistry ...	Upendra Nath Mitra.
Ditto ditto Physical Science	Sarat Chandra Bose.

Apprentice Department.

Head Master and Lecturer on Chemistry	R. W. F. Shaw, M.A.
Teacher	P. W. Byers, L.C.E.
Ditto	Hari Charan Mukerjee, L.E., (On leave).
Ditto	Purnendra Chakravarti, Officiating
Ditto	Chuni Lal Sircar, B.E.
Assistant to Lecturer on Chemistry ...	Giris Chandra Bose.

Workshops.

Foreman Instructor	W. G. Lawrence.
Ditto	A. F. Burnie.

Ten native instructors.

Hostels.

Superintendent of European Mess ...	R. W. F. Shaw, M.A.
Ditto Native Mess ...	Ashutosh Ganguli.

Gymnastics.

Gymnastic Teacher ... ... Nogendro Nath Banerjee.

Medical Officer.

Assistant Surgeon Brojo Nath Shaha.

CIVIL ENGINEERING COLLEGE, SIBPUR.

ENGINEER DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal is charged with the general control of the College and Workshops, including the regulation of the course of instruction, both theoretical and practical, the supervision of the messes and other domestic arrangements, and the maintenance of discipline, and he will from time to time issue such rules as may be necessary to secure those objects.

Rules for Admission.

3. For admission to the Engineer Department, a student must have passed one of the following tests:—

(1) The F.A. Examination of the Calcutta University or a similar standard of any Indian University, recognized by the Calcutta University. The candidate's age must be under 21 years.

(2) The B.A. Examination in the B. course in Physics and Chemistry, in Mathematics and Science. The candidate's age must be under 23 years. (These students are admitted direct into the second-year class.)

Every candidate for admission to this Department must apply in writing to the Principal not later than the 15th May, furnishing satisfactory proof of having passed one or other of the examinations mentioned above.

4. The number to be admitted each year is limited to 40. The position in the University examination and the age of candidates will be taken into consideration when selection is made, and such selection will be made by the Principal.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Each student received into the College will be required to pay an admission fee of Rs. 10.

7. The session begins on the first Monday in June. All students are required to join the College on that day. Any students prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he

will be liable to a fine not exceeding Rs. 10. No student will be admitted or re-admitted to the College after the close of the month of June, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. The course of instruction in the Engineer class will extend over five years, during the first four of which the instruction will be both theoretical and practical. The last year will be spent entirely in practical work. For details of the course of study, *see* Syllabus.

9. The students of the Engineer Department will be divided into sections—A, Civil; B Mechanical.* Both sections will attend the same lectures for the first three years, and the students will then present themselves at the first examination in Engineering of the Calcutta University, which is held in the month of May. After passing this examination the sections will separate, the students of each section attending only those lectures which will enable them to qualify at the examinations of the Calcutta University for degrees or licenses in Civil or Mechanical Engineering.

* This section has not yet been established.

10. After the expiration of one year from the date of passing the first examination in Engineering, students will be qualified to appear at the University examination for degrees or licenses.

Extract from the "Calcutta Gazette" *of the 16th March 1887, page 79, Part IB.*

"A candidate for employment as District Engineer must be qualified in one of the manners following, that is to say, he must—

(5) Hold the degree of Bachelor of Engineering or be Licentiate of Engineering of the Calcutta University, and have been employed on engineering works for not less than five years, exclusive of any time spent on apprenticeship, and hold satisfactory certificates of good conduct and efficiency during such employment."

11. After qualifying for a University degree or license in Engineering, every student will be employed for one year on practical work only, either in the workshops or on works in progress. On completing this course to the satisfaction of the College authorities, he will be entitled to receive the final College certificate.

12. A student failing at either the first or the second University examination may, with the sanction of the Director of Public Instruction, on the recommendation of the College authorities, be permitted to attend the College for one year more in order to re-appear at the examination; but no student will be allowed to attend the College course after the expiration of five years from admission. A student failing at the second examination will be allowed to attend the practical course for one year. The final College certificate shall state whether the student has or has not taken the University degree in Engineering, and in which branch, and whether he has or has not completed the course of practical work to the satisfaction of the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. Students will attend daily in the class room and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year. The fourth-year class is excused from work in the shops.

14. The rules for the transfer of Engineer students to the Apprentice Department are as follows:—

(*a*) First and second-year Engineer students may apply for transfer to the Apprentice Department immediately after the result of their annual examination is published. Transfers cannot be made at any other time of the year.

(*b*) No student can be transferred who has failed in the practical examination immediately preceding his application for transfer.

(*c*) First-year students may be admitted to the first year, and second-year students to the second-year class of the Apprentice Department: these students must pass the annual examination of the class to which they are transferred in both theory and practice before they can be promoted to a higher class.

(*d*) No student who has once been transferred to the Apprentice Department can be re-admitted to the Engineer Department.

(*e*) The age of a student on transfer must be below 17 years and 4 months if transferred to the first-year class, and below 18 years and 4 months if to the second-year class of the Apprentice Department.

15. There will be a long vacation from about the middle of August to the end of October. Every student must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

Tuition Fees.

16. The tuition fee for students of the Engineer class is Rs. 8 a month for each month of the year, vacation included. Muhammadan students are admitted on payment of half fees, viz., Rs. 4 a month.

Scholarships.

17. For the present, one junior scholarship of the value of Rs. 20 a month, three of Rs. 15 a month, and six of Rs. 10, tenable for two years, will be given annually to students entering the first-year Engineer class who do not already hold University scholarships. The scholarships will be awarded by the Director of Public Instruction on the last day of June to the following classes of students in order:—(1) B. A.'s who have taken up the B. course; (2) F.A. candidates.*

18. Senior scholarships of the same number and value will be competed for at the annual examination held in May for the promotion of students from the second to the third-year class.

* Except those who passed in the 3rd division.

19. The number of College scholarships awarded, whether junior or senior, will in no case exceed one-half of the number of candidates for them.

20. Two scholarships of Rs. 10 a month each, tenable for one year, called Forbes' scholarships, will be awarded on the result of the first examination in Engineering of the Calcutta University. A Forbes' scholar, unless he also holds a College scholarship, will be exempted from paying the tuition-fee of Rs. 8 a month.

21. On the result of the University examination for degrees and licenses, six graduate scholarships of Rs. 50 each, tenable for one year, and two graduate mining scholarships of Rs. 50, tenable for two years, will be awarded. The mining scholarships will be reserved for holders of the B.E. degree, and will be awarded to those who propose to take up mining as a profession. In the event of there being no candidate for a mining scholarship, the total number of graduate scholarships awardable will be ten, each of Rs. 50, tenable for one year; and in the event of one mining scholarship only being taken up, then eight of Rs. 50 each, tenable for one year, will be awarded. The one-year scholarship-holders must serve continuously during that period in practical work under the supervision of the Public Works Department, and to the satisfaction of those under whose orders they may be placed. The mining scholarships would be tenable on a mine approved by Government, and would be payable monthly on a report that the holders continued to work satisfactorily under the orders of the Mine Superintendent. The two years' service will be reckoned as one year on practical work under the supervision of the Public Works Department. Each of these years will extend over a session of nine months' service in a mine, and three months' training in assaying either under the Superintendent of the mine or in the Sibpur College, as may hereafter be determined.

22. A gold medal will be awarded to the student who gains the highest marks in mathematics at the examination for the B.E. degree. The holder of this medal will be styled the "Ambica Churn Chaudhuri Medallist." A silver medal will be awarded to that candidate at the L.E. and B.E. examination who, not having won the gold medal, obtains the highest number of marks.

23. All scholarships will be liable to forfeiture in case of misconduct, or of neglect of work in class or in the field, or of failure to pass any prescribed examination.

Standing Orders for Students.

24. Except with the special sanction of the Principal, students of the Engineer Department will be required to reside on the College premises, so far as the accommodation will permit, at a rent to be fixed from time to time by the Government. The present rate is Rs. 2 a month for both European and native students. This charge will be levied all the year round, except during any period in which the student may be in camp.

25. Each resident student must provide his own clothing and bedding and a camp bedstead. No furniture may be brought into the College without special permission.

European Mess.

26. Every resident European student will join the European mess. A charge of Rs. 20 a month will be made to defray the cost of messing. During the vacation, reckoned at 2½ months, each European student will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Rs. 2 towards the cost of maintaining mess servants.*

27. On joining the mess, every student will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table-linen, &c. A list of breakages and other damage done will be prepared monthly, and each student will be required to pay by the 15th of the following month an equal share of the cost. On leaving the mess, if a student has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

28. For students joining the European mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	1	2	3	4	5	6
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Term ...	8	20	2	30	285	315
Vacation ...	8	2	2	12	30	

Native Mess.

29. Hindu students residing on the College premises must ordinarily join the College mess for natives, and must abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

30. A charge of Rs. 7 a month will be made to those joining the native mess. During the vacation of two months, every member of the mess will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Re. 1 for mess servants.

31. For students joining the native mess, the following table shows the annual cost of living at the College, the term being reckoned as

* European students have, at their own request, established a private mess, the cost of which is about Rs. 30 per mensem.

nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	1	2	3	4	5	6
	Rs.	Rs.	Rs.	Rs.	Rs. A.	Rs.
Term ...	8	7	2	17	161 8	189
Vacation ...	8	1	2	11	27 8	

32. All payments, whether on account of tuition fees, messing or house-rent, must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting student's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines and the usual re-admission fee.

33. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

34. All breaches of discipline committed by any student of the College will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

35. A Conduct Register of each student in the College will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

36. Students are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(*i*) Disobedience of orders.
(*ii*) Absence without leave.
(*iii*) Idleness.
(*iv*) Insubordination or disrespect to the College or Workshop authorities.

37. Students may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal shall be reported to the Director of Public Instruction, and any fees paid by the student shall be forfeited.

38. Every student will be responsible for any machines, tools or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

39. A certain number of the students will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance

of discipline. For the performance of this duty, each monitor will receive a small sum monthly. Any monitor may be removed by the Principal for misconduct, or for inefficiency in the discharge of his duties.

40. No resident student will ordinarily be allowed to keep a private servant. This permission may be given under exceptional circumstances, but any servant so employed will be under the orders of the Principal.

41. On Sundays all resident Christian students, Protestant or Roman Catholic, will be required to attend the services held in their respective chapels.

42. All students will be required, while in the workshop, to wear a uniform dress, which will be supplied to them at cost price.

43. Leave will be granted by the Principal only. No leave will be granted except on a written application.

44. No resident student may leave the College premises without the written order of the Principal, whether on special leave or on a general holiday.

45. European students will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

46. One appointment is guaranteed yearly to students of the College who are statutory natives of India. The selected student is posted as Apprentice or Assistant Engineer in the Provincial Establishment, Public Works Department. In alternate years an ex-student already employed in the Public Works Department will be selected for promotion from the Subordinate to the Engineer Establishment, Provincial Branch.

47. All students are obliged to join the College Athletic Club, the subscription to which is Rs. 3 per annum and the entrance fee Re. 1.

ENGINEER DEPARTMENT.

List of Books and Instruments to be procured by Engineer students.

Students will provide themselves with the following books and instruments:—

First year ...
- Hall and Steven's Euclid.
- Hall and Knight's Higher Algebra.
- Todhunter's Trigonometry.
- Ramsay's Elements of Chemistry.
- Davidson's Linear Drawing.
- Davidson's Projection.
- Bloxam's Metals.
- Roorkee Treatise on Surveying.
- A good box of drawing instruments and set squares.

Second year..
- Lock's Elementary Statics.
- Ditto Dynamics.
- Wilson's Geometrical Conic Sections.
- Deschanel's Heat
- Sylvanus Thompson's Elementary Lessons on Electricity and Magnetism.
- Brooker and Slingo's Electrical Engineering.
- Roorkee papers on Estimating.
- Building Construction, South Kensington Series, Vols. I and III.

Third year...
- Smith's Conic Sections.
- Preece and Sievewright's Text-book on Telegraphy.
- Heath's Geometrical Optics.
- Building Construction, South Kensington Series, Vols. II and IV.
- Goodeve's Mechanism.
- Austen's Introduction to the Study of Metallurgy.
- Box of blow-pipe utensils.

Fourth year...
- Todhunter's Differential Calculus.
- „ Integral „
- Besant's Hydrostatics.
- Bauerman's Descriptive Mineralogy.
- Geikie's Outlines of Geology.
- Jamieson's Steam Engine.
- Wray's Instruction in Construction.
- Love's Hydraulics.
- Barry's Railway Appliances.
- Roorkee papers on Bridges, Roads, and Irrigation Works.
- Box of blow-pipe utensils.

ENGINEER DEPARTMENT.

SYLLABUS OF INSTRUCTION.

1.—MATERIALS OF CONSTRUCTION.

CLASSIFICATION ... { (*a*) Stone, brick, tiles, terra-cotta, timber metals.
(*b*) Limes, cements, mortars, concretes, plasters.
(*c*) Mastics, glue, paints.

STONE.

Characteristics of Building Stone.—Durability dependent on atmospheric influence and physical structure. Facility of working; hardness; strength; weight; appearance; position in quarry; seasoning; natural bed; agents which destroy stone.

Examination of stone.—Fracture. Tests:—crushing; absorption; Brard's test; acid test; Smith's test. Practical way of ascertaining weathering qualities.

Classification of stone. Scientific.—Siliceous, argillaceous, and calcareous. *Practical.*—Granites and other igneous rocks; slates; sandstones; limestones.

Granite.—Common granite. Syenite and syenitic granite; quarrying and dressing: uses to which granite is applied.

Igneous rocks other than granite.—Porphyry, gneiss, mica schist, hornblende schist, trap, basalt.

Slates.—Cleavage, plerry, quarrying, hardness, toughness, grain, veins objectionable, pyrites. Tests.

Sandstones.—Composition, colour. Practical classification. Fracture a test of quality. Weight and absorption.

Limestones.—Composition, texture, marbles, compact limestones, granular limestones, shelly limestones, dolomite.

Artificial stone.—Ransome's, Sorel's, Victoria stone, Garlick stone.

Preservation of stone.—Bituminous matter, drying oil, silicate of potash, silicate of lime.

Quarrying.—Mode of conducting quarrying operations n India. Blasting.

BRICKS, TILES AND TERRA-COTTA.

Brick-earths.—Effect of the following ingredients in brick-earths:—Alumina, silica, lime, carbonaceous matter, alkalies, salt, oxide of iron, reh.

Practical classification—Strong clays; loams, marls, malm.

Composition of a good brick-earth. Colour of bricks.

Brick-making—Preparation of brick-earth.—Unsoiling, digging and weathering, grinding, washing, tempering.

Moulding.—Slop moulding, sand moulding, pallet moulding, frog, form of mould, and size of brick.

Drying.—In sheds, out of doors, hacking, scintling.

Burning.—In clamps, in kilns, amount of fuel required, comparative advantages of clamp and kiln burning, Hoffmann's kiln, Bull's kilns.

Characteristics of good bricks.—Freedom from flaws, shape, absorption, texture.

Tests for bricks.—Fractured surface, Brard's test.

Fire-clay.—Uses, where found, composition.

Tiles.—Preparation of clay, moulding pot, and flat tiles, various forms of tiles in use in India.

Terra-cotta.—Nature of clay, preparation of clay, moulding, glazing, burning.

Limes, Cements, Mortars, Concretes, Plasters.

Constituents of limestone that do not produce hydraulicity.—Carbonate of lime, sand.

Constituents that produce hydraulicity.—Clay, soluble silica, carbonate of magnesia, alkalies, sulphates.

Classification of limes and cements.—Fat limes, poor limes, hydraulic limes, cements.

Varieties of lime in common use.—Fat limes, grey chalk, lias, carboniferous, magnesian ; limestones used in India ; kunkur.

Artificial hydraulic lime. Natural cements.—Carbonate of magnesia, cement stones.

Roman cement.—Weight, strength, storing, uses. Medina and Atkinson's cements.

Artificial cements. Portland cement.—Manufacture from chalk and clay. Manufacture from limestones and shale. Tests of quality. Rough tests. Storing. Strength when mixed with sand. *Scott's cement. Selenitic cement. Pasley's cement.*

Lime and cement burning.—Forms of kilns. Flare and tunnel kilns. *General rules for burning.*—Heat gradually applied, temperature, size of lumps, quantity of fuel, appearance of stone while burning. Overburnt and underburnt cements. Dead-burnt lime.

Sand.—Pit sand, river sand, sea sand, screening and washing sand. Examination of sand.

Pozzuolanas.—Natural and artificial pozzuolanas.

Mortar.—Ordinary mortar, cement mortar. Evils of fat limes. Hydraulic limes. Cements. Description of sand to be used in mortar.

Water.—Salt water, dirty water.

Preparation, and mixing mortar.

Slaking lime.—Quantity, time. Ground lime. Water.

Mixing.—Methods, quantities ; bulk of mortar produced.

Precautions in using mortar.

Concrete.—The matrix. The aggregate ; shape, size. Aggregates in common use :—Broken brick. Burnt clay. Gravel. Ballast. Slag. Voids. *Proportion of ingredients. Mixing :*—Materials all mixed together: mixed separately. Relative advantages of the two methods.

Laying concrete :—In trenches. Under water. *Bulk of concret produced. Expansion of concrete. Uses of concrete.* Coignet's Béton *Strength of concrete. Monolithic structures in concrete.*

On the action of foreign constituents in limestones and cements. Fa limes :—Calcination. Slaking. Setting. Mortar. Action of sand *Hydraulic limes and cements containing clay.*—Clay. Lime. Calcination Proportion of clay. Effect in cements burnt at a moderate tempera ture. Effect in cements burnt at a high temperature. Composition o clay. Effects caused by different degress of calcination. Hydrauli limestones. Cement stones containing a small proportion of clay Cement stones containing a large proportion of clay. Slaking. Set ting. Proportion of clay. Pozzuolana. Carbonate of magnesia Sulphates.

Plasters :—Lime and cement plaster. Gypsum. Plaster of Paris. Stucco.

Asphaltes :—Characteristics of good asphalte. Methods of laying. Uses.

White-wash.

Paints and Varnishes.

Paints. Distemper. Varnish. Mastics. Glazing. Papering.

Timber.

Growth of trees.—Annual rings, medullary rays, sapwood, heart-wood, felling, squaring.

Characteristics of good Timber.

Defects in timber.—Heartshakes, starshakes, cupshakes ; rind galls, upsets, foxiness, twisted fibres.

Classification of timber.—Pine wood or soft wood, leaf wood or hard wood.

Seasoning timber.—Natural seasoning, water seasoning, boiling and steaming, hot air seasoning, smoke-drying, scorching and charring.

Causes of decay in timber.—Continued dryness ; continued moisture alternate dryness and moisture ; continued moisture with heat. Dry rot. Positions in which dry rot occurs. Detection of dry rot, checking dry rot. Wet rot. Positions in which wet rot occurs.

Destruction of timber by insects.—Destruction by marine animals and whiteants, and modes of protecting timber from their attacks.

Preservation of timber.—By good ventilation and obviating moisture. By the use of oil paint. By the application of tar boiled with powdered chalk. Bethell's process of creosoting. Boucherie's process of injecting sulphate of copper. Margary's process. Payne's process.

Measurement of timber.

Metals.

Iron ores.—Blackband. Red and brown hæmatite, magnetic, spathic, argillaceous.

Preparation of ores.—By washing. By roasting in clamps and in kilns.

Smelting.—Description of blast furnace. Hot blast. Cold blast. Flux, slag. Comparative advantages of hot and cold blast iron.

Pig iron.—Foreign substances in pig iron. Carbon in a state of mechanical mixture and in chemical combination with cast iron. Effects of the following impurities upon cast iron, wrought iron and steel:—Silicon, phosphorus, manganese, sulphur.

Cast iron.—Remelting pig iron. Grey and white cast iron, mottled cast iron. To distinguish grey from white. Chilled iron. Malleable cast iron. Toughened cast iron. Descriptions of pig iron for casting in sand. Pattern. Cold shut, core, head, casting pipes, examination of castings, cast iron pipes, tests for cast iron.

Production of Wrought Iron.

Effect on pig iron of—Refining, puddling, shingling, rolling: contraction of wrought iron, defects in wrought iron, cold-short, hot-short, or red-short. Mitis castings.

Tests for wrought iron.—Tensile strength. Ductility. Methods of testing. Tensile tests, forge tests, testing rivets, appearance of fractured surface.

Market forms of wrought iron.

Production of Steel.—Amount of carbon in steel. Characteristics: —hardening, tempering. Varieties of steel; blister steel; spring steel; shear steel; cast steel; Bessemer process; Siemens-Martin process; Basic process.

Hardening and tempering steel.—Table of temperatures and colours. Degree of heat for hardening and methods of cooling. Hardening and tempering in oil.

Case hardening.

To distinguish steel from wrought iron. Testing steel.

Forging iron.—The form to be given to forgings, overheating.

Forging steel.—Shear, blister and cast steel.

Welding.—Wrought iron, steel.

Preservation of iron.—Corrosion, galvanising, painting, Dr. Angus Smith's process for cast iron pipes, Barff's process, Bright iron work.

2.—CONSTRUCTION.

Brick-laying.

General principles of brickwork. Bond.

Operations of brick-laying. Bond timber objectionable. Mortar joints. Fine joints. Lime putty.

Precautions against settlement. Joining new work to old. String courses and copes. Stone quoins.

Scaffolding.

Masonry.

General principles of stone masonry. Ashlar. Block in course. Coursed rubble. Common rubble. Rubble backing. Strength of a mass of masonry as depending on the size of stones, the bond, and accuracy in dressing. Bonding—headers and stretchers; through bonds.

Quoins. Direction of beds in battering walls. String courses and copes. Pointing. Drystone masonry. Mechanism for moving large stones.

Instruments used in building. Scaffolding.

Earthwork.

Preliminary arrangements to be undertaken by the Engineer. Preparation of plan and sections. Practical stability of earthwork. Of excavation in rock.

Setting out of earthwork. Base or formation level. Sides or slopes. Half breadths. Computation of volume of a piece of earthwork. Simpson's rule for volumes. Prismoidal formula. Use of tables in such computations. Setting out. Angles. Centre line. Side widths; on side-long ground. Use of the bevil plumb rule, clinometer, mason's level, and boning staves.

Execution of earthwork. The tools and implements used. Size and form of barrows. Distribution of labour. Dobbin carts. Earth wagons. Boring to ascertain nature of ground.

Cuttings. Equalisation of cuttings and embankments. Side cuttings. Spoil banks. Stripping the soil. The consecutive operations in forming a heavy cutting. The horse run with large barrows. Casting up by stages. Slips. Drainage.

Embanking and puddling. Preferable materials for embankments. Embankments formed in one layer. In two or more thick layers. Settlement of embankments. Side slopes, facing slopes. Embanking in side-long ground. Foundations of embankments. Punning. Trimming slopes.

Carpentry.

Joints and Fastenings.

Joints.—Lapping, fishing, scarfing. Different forms of scarf. Halving. Dovetails. Notching. Cogging. Mortise and tenon joint. Chase mortises. Circular joints. Bridle joints. Post and beam joints. Strut and beam joints. Tie and brace joints. Suspending pieces. Wedging. Fox-wedging. Keys.

Fastening. Pinning:—Nails, spikes, trenails, screws. Bolts, washers, plates. *Straps:*—Heel straps, branched straps. Cast-iron shoes and sockets. Tie-beam plates. Shoe for foot of rafters. Double shoe. Socket pieces. Protection of iron fastenings from decay.

Built beams and ribs of timber. Trussed beams of timber.

Floors.—Single floors, double floors, framed floors; wall plates, templates. Common joists, strutting joists, trimming joists. Floor boards. Ceiling joists. Precautions to be observed in laying floors, with respect to door and window openings and partition walls.

Partitions.—General remarks. Framed without doorway. With ordinary doorway in centre. With side door. Common partition. Brick-nogged partitions.

Timber Roofs.—Flat roof. Pitch of roof. Couple roof. Couple-close roof. Collar beam roof. King bolt roof without struts. King post roof. Queen post roof. Purlins. Rafters.

Stairs.—Dimensions of stairs. Rule for proportion of rise to tread. Method of laying out stairs. *Different forms of stairs :*—Straight, dogged-legged, geometrical. *Parts of wooden stairs :*—Strings, steps. General rules for planning stairs.

Doors and windows.—Ledged doors, ledged and braced doors, panelled doors, glazed doors. Door frames. Fixed sashes. Fanlights. Sashes hung on centres. General arrangements of sliding sashes.

Foundations.

Importance of slight and uniform settlement. Various modes of attaining that object. Action of water on foundations. Various conditions dependent on nature of bearing strata.

Importance of ascertaining the character of bearing strata. Trial pits. Borings.

Dry foundations. Rock. Gravel. Sand. Mixed strata of rocks and clay. Shale. Clay. Expansion of clay when exposed. Bearing stratum underlying soft ground of considerable depth. Crust of good ground overlying soft substratum.

Mechanical construction of foundations. Footings. Planking. Use of sand, concrete and béton.

Land foundations on artificial bottom. Consolidation of soft ground by driving piles. Platforms of fascines, timber or concrete, forming floating foundations.

Foundations on good natural bottom under water. Piled foundations. Timber piling. Cast and wrought iron piling. Iron screw piles. Hollow cast iron cylinders. Brick wells, as employed in India. Sand pump. Solid foundations laid under water. Pierre perdue. Random blocks of béton. Béton laid in caissons lined with tarpaulin. Solid masonry built on the natural bottom by divers. Solid masonry in cribs.

Foundations on sites where the water can be temporarily excluded. Solid masonry sunk in caissons on a bottom dredged out and levelled with béton. The same on a piled bottom. Solid masonry built in a cofferdam.

Arching.

Names of parts—Different forms of arches. Inverted arches.

Brick arches.—Rough brick arches, axed arches, gauged arches.

Arches over openings in wall.—Segmental face arch, semi-circular arch, straight arch.

Stone arches.—Ashlar. Rubble.

Buildings.

Selection of site—Design of foundations and preparation of bed. Thickness of walls. Points to be attended to in building walls. Buttresses. Arches in walls. Floors of various kinds. *Roofs.*—Different forms of trusses in wood and iron. *Roof covering.*—Various materials used for this purpose, and mode of applying. Ceilings, chimneys, fire-places. Doors and windows. Drainage and ventilation, lightning-conductors.

Bridges.

Temporary expedients for crossing rivers.—Causeways, temporary bridges, ferry boats, boat and pontoon bridges, rope bridges.

Masonry Bridges.—Details of the various parts in brick and stone, with principles of design.

Wooden Bridges.—Various forms of trusses and details of parts.

Iron and Steel Bridges.—Different forms of girders used, with full details of joints, roadway, &c., and mode of calculating the strength of the various parts. Methods adopted for erecting bridges.

Roads.

Fair-weather roads in districts liable to inundations. Permanent roads. Resistance of vehicles on roads variously paved. Ruling gradients. Staking out the centre line. Formation. Breadth and cross section. Earthwork. Side slopes. Culverts and drains. Road metalling. Paving with stone blocks. Maintenance and repairs. Hill roads. Street paving in towns.

Railways.

Survey and choice of line. Gradients and curves. Resistance of railway trains on a level straight line. On curves and steep gradients.

Formation of roadway. Earthworks. Formation level. Base. Culverts. Regulations about bridges. Level-crossings. Fencing. Mile-posts. Gradient posts.

Permanent-way of railways. Gauge of railways. Ballast. Timber sleepers. Rails. Chairs. Rail joints, fish joints. Cast iron sleepers. Wrought iron sleepers. Cant of rails. Elevation of outer rail on curves. Sidings. Switches and crossings. Turn-tables.

Railway stations. Design and arrangement. Classification. Terminal stations. Intermediate stations. Selection of site. Details of terminal stations. Approaches, roads and yards. Position of principal buildings. Parallel or side-station system. Transverse or end-station system. Goods stations. Goods yard at small stations. Signals.

Irrigation Works.

Well-irrigation.—Common machinery employed in India for raising water from wells.

Canal irrigation. Inundation canals.—General rules for tion of best site for head works. Head sluices. Slope of bed.

Permanent canals.—Sources of supply, amount of water required, slope of bed, discharges of canals, section of channel, alignment of canal. Head works—weirs, regulators; falls, rapids, locks, navigation channels, aqueducts, inlets, level-crossings, super-passages.

Distribution of water.—Rajbahas. Modules.

Tank irrigation.—Site of embankment. Different forms of embankment. Waste weirs. Irrigation sluices.

River inundation and river improvement.—General methods in use to improve the course of streams, and to render channels navigable.

3.—ESTIMATING.

General principles of estimating. Rules of mensuration of surfaces and solids.

The student will be exercised in taking out quantities and framing an estimate from working drawings of the following examples :—

A masonry culvert. A portion of road in cutting and embankment. A house. A wooden bridge. An iron bridge. A masonry bridge.

4.—APPLIED MECHANICS.

Definitions.

Elasticity.—Plasticity and rigidity. Stress, its nature and intensity. Tensile, compressive, and shearing stresses. Positive and negative senses of a stress. Stresses of uniform and variable intensities. Ultimate strength. Factor of safety.

Tension.

Simple tension.—Work done in stretching a rod. Thin pipes under internal fluid pressure. Strength of prismatic solids under tensile stress when the resultant of applied forces does not coincide with the axis of the solid. Safe tensile co-efficients of various materials.

Compression.

Classification of bars or pillars under compression :—Very short pillars, short pillars, long pillars, very long pillars. Methods of failure of these classes of pillars. Rondolet's, Hodgkinson's and Gordon's formulæ. Euler's formula. Fairbairn's formula for collapsing of tubes under fluid pressure. General remarks on the applicability of the above formulæ. Safe compressive co-efficients of materials usually subjected to a compressive stress : impact, pile driving.

Transverse Strain.

Proof that the stress at each point varies as its distance from the neutral axis.

Determination of the position of the neutral axis.

Determination of the moment of resistance.

Calculation of moments of inertia of ordinary sections used in engineering construction.

Flanged girders :—Approximate and accurate methods.

Proportion of I beams for equal strength.

Beams of uniform strength.

Bending moments and shearing forces.—(Treated graphically and analytically).

Cantilever under single load at free end.

Cantilever under uniformly distributed load.

Cantilever under uniformly distributed load, and one or more detached loads.

Beams supported at the ends and loaded with detached loads at any point.

Beams supported at the ends and loaded uniformly.

Beams supported at the ends and loaded uniformly, and also with one or more detached loads.

Beams supported at the ends and loaded with a single detached moving load.

Beams supported at the ends, supporting an uniformly distributed moving load of length less than the span.

Beams supported at the ends, supporting an uniformly distributed moving load of length greater than the span.

Beams supported at the ends and loaded at intermediate points.—Conversion of detached loads into equivalent uniformly distributed load.

Statics of Structures.

Framework loaded at the joints.

Triangular frames.—Diagram of forces for a single triangular frame. Triangular trusses. Cranes and derricks. Sheer-legs and tripods. Effect of the tension of the chain in cranes.

Incomplete frames.—Preliminary ideas. Simple trapezoidal or Queen post truss. General case of a funicular polygon under a vertical load. Suspension chains.

Compound frames.—Compound triangular frames for bridge trusses. Roof trusses in timber. Queen truss for large iron roofs. Diagram of forces in general.

Framework girders.—Warren girders under various loads. N trusses. Bowstring girders.

Girders with redundant bars.—Lattice girders, flanged beams.

Deflection of Beams.

Deflection due to the maximum bending moment. General equation of deflection curve. Elementary cases of deflection and slope. Beams propped in the middle. Stiffness of beams. Stiffest beam that can be cut from a circular log.

Shearing.

Distinction between tangential stress and normal stress. Equality of tangential stress on planes at right angles. Tangential stress equivalent to a pair of equal and opposite normal stresses. Web of a beam of I section. Method of computing the intensity of the shearing stress at any point in a bent solid.

Resistance of Prismatic Solids to Simple Torsion.

Explanation of the phenomena of simple torsion.

A circular section, solid or hollow, most favourable form of prismatic solid for resistance to torsion.

Twisting moment. The limiting intensity of the resistance to torsion is that of the shearing stress.

Investigation of the resistance of a circular prism to torsion round its mean fibre.

The strength of axles subject to simple torsion. Values of the limiting intensity of working resistance to simple torsion for different materials.

Diameter of a shaft to transmit a given power.

Blockwork Structures.

Stability at a plane joint. Stability of a series of blocks. Centres of pressure or resistance. Line, polygon and curve of pressures. Line of resistance, or polygon of centres of pressures. Moment of stability.

Retaining walls.—Theory of earth pressure. Angle of repose of different soils. Walls supporting a bank of earth with horizontal surface. Surcharged walls. Graphic methods of solution. Determination of the centre of pressure on any joint of a wall supporting a load of earth at its back. Maximum intensity of stress at any joint in a retaining wall. Minimum intensity of pressure. Tensile stress at a joint. Effect of cohesion of mortar. Connection between maximum intensity of pressure on foundation course and power of resistance of earth foundation. Methods of equalising intensity of stress on foundation courses.

Masonry arches.—Definitions. Curve of pressures and line of resistance. Conditions of stability. Treatment of the weight of loads of different densities. Graphic process of determining the stability and resistance of any proposed arch by drawing the line of resistance. Depth of key-stone.

Stability and resistance of abutments and piers.—Graphic process of determining the position of resultant pressure on any joint of an abutment. Design of piers.

Stability of foundations of structures in masonry and brickwork.

5.—HYDRAULICS.

1. General Principles.

Velocity and volume of flow. Principle of continuity. Flow in a stream. Steady and varying motion of streams. Fluid acting on piston. Theorem of Bernouilli. Hydraulic head.

2. The Flow of Liquids through Orifices.

Application of the theorem of Bernouilli. Velocity of flow due to given head. Co-efficient of velocity. Co-efficient of contraction. Co-efficient of discharge. Co-efficient of resistance. Connection between co-efficients of velocity and resistance. Discharge from large rectangular orifices. Borda's mouth-piece. Co-efficient of contraction for Borda's mouth-piece obtained theoretically. Incomplete contraction Cylindrical and conical mouth-pieces. Flow over notches. Triangula

notches. Velocity of approach. Application of results to measurement of flow in streams. Francis' formula. Discharge of measured quantities of water for irrigation purposes. Italian and Spanish modules. Other forms of apparatus answering the same purpose. Discharge under varying head. Jet pump. Separating weirs.

3. The Flow of Liquids in Pipes.

Laws of friction between liquids and surfaces. Froude's and Unwin's experiments. Loss of head due to friction in pipes. Hydraulic mean depth. Variation of co-efficient with velocity and diameter. Darcy's formula. Hydraulic gradient. Ordinary computations of size of pipes and volume of discharge. Loss of head due to bends, elbows, enlargements, &c.

4. Movements of Water in Canals and Rivers.

Mean velocity corresponding to given gradient. Variation of the co-efficient. Velocity at different parts of the section of the stream. Mean velocity in terms of surface and bottom velocity. Ratio of mean to maximum velocity. Forms of section of channel, circular, trapezoidal, egg-profile. Most economical section of channel with given side-slopes. Form of section for a constant velocity with varying discharge.

5. Impulse and Reaction of Water.

Pressure of a jet on a plane surface fixed or moving. Energy communicated to the moving surface and efficiency of jet. Velocity of surface for maximum efficiency. Resultant pressure on curved surface, direct impulse and reaction. Condition to avoid loss by shock when jet is received. Condition for least loss of kinetic energy when jet is discharged.

6. Hydraulic Machines.

Transmission of energy by hydraulic pressure. Power of hydraulic motors. Causes of loss of efficiency in water pressure engines, pumps, accumulators, and water-wheels.

Principle of momentum as applied to rotating machines; turning couple equal to the change of moment of momentum.

Speed for maximum efficiency and losses in reaction wheels.

Most efficient speed of turbines. Angles of moving and guiding vanes. Forms of vanes. Losses of efficiency. Regulation of power of turbines. Estimation and graphical representation of the diminution of total and pressure-head in flow through a turbine.

Centrifugal pumps with radial vanes. Speed for given lift with given efficiency. Utilisation of kinetic energy of whirl. Best form and dimensions of spiral chamber. Whirlpool chamber. Centrifugal pump with backward curved vanes. Losses. Volume discharged.

Efficiency of propellers. Jet propellers. Paddle-wheel. Screw.

6.—MECHANICAL ENGINEERING.

Description and Construction of the Elementary Pieces of Machines.

Shafting. Couplings. Clutches. Friction clutches. Plummer blocks or pedestals. Fixings, wall boxes, brackets, hangers. Footsteps. Bolts and nuts.

Tooth gearing. Spur wheels. Racks. Bevil wheels. Worm gearing. Modes of fixing wheels upon shafts.

Driving belts. Drums and pulleys. Fixing drums and pulleys upon shafts. Rope transmission. Telodynamic transmission.

Cranks. Eccentrics. Cams. Connecting rods.

Valves. Pistons. Stuffing boxes.

Steam Engine.

Fuel and combustion.—Chemical composition and physical properties of the different kinds of fuel. Calorific value of some elements and their compounds. Determination of the calorific value of the different kinds of fuel. Process of combustion. Formation of smoke and flame. Losses by incomplete combustion. Air necessary for combustion. Temperature of combustion. Density of burnt gas. Maintenance of draught, by convection; by artificial means. Transmission of heat from furnace gases. Waste of heat. Methods of stoking. Mechanical stokers.

The Boiler.—Types of boilers. Proportions to provide sufficient grate and heating surfaces. Proportions and methods of construction to provide sufficient strength. Construction to facilitate cleaning and examination. Boiler fittings.

The Steam Engine in general.—Types of engines. Horse-power. Relations between dimensions of cylinder, speed of piston or revolution, and power of engine. The design of the principal details of an engine. Piston, piston rod, connecting rod, crank shaft. The slide valve and eccentric. Link motions. Expansion valves. Zeuner's valve diagrams. The Indicator and Indicator diagrams. The condenser and air pump.

The Locomotive Engine.—Train resistance. Tractive power. Adhesion. Express and coupled engines. General description of ordinary engines. Goods engines. Limit of load on wheels. Fatigue of rails. Description of engines for exceptional circumstances. Engines for steep inclines. Engines for exceptionally heavy trains on moderate inclines. Engines for narrow gauge lines. Double traction. Fairlie engines.

General arrangements of engine and boiler. Reversing. Expansive working. Webb's compound engine. Brakes. Framing. Axle boxes. Springs. Axles. Wheels. Effect of curves on wear of tires. Provisions for reducing the effect of sharp curves. The tender. Ramsbottom's scoop.

Thermodynamics.

Measurement of temperature and quantities of heat. Relations between pressure, temperature, and volume of steam. Total heat of formation of steam.

External work done during evaporation. Relation between heat and work; Joule's equivalent. Internal work of evaporation.

Operation of a non-expansive working engine. Expenditure of heat and steam. Efficiency. Condensation water.

Calculation and graphical representation of the energy exerted by an expanding fluid. Relation between pressure and volume of expanding steam. Indicator diagram. Mean pressure.

Transmission of heat to and from metal of cylinder when steam is used expansively, and consequent limitation of economical ratio of expansion. Expenditure of heat and steam in expansive working engine. Efficiency. Advantage of steam jacket and superheating. Operation of compound engine. Indicator diagrams. Advantages of compound engine.

Efficiency of thermally perfect air engine. Reversibility. Carnot's principle. Maximum efficiency of any heat engine.

7.—SURVEYING.

Lecture Room Course.

(1) Construction of scales—Simple, diagonal, and vernier.

(2) Useful problems in surveying.—To avoid obstacles in the chain line—

1st—When the obstacles can be seen over and chained round, but not across.

2nd—When it can neither be seen over nor chained across, but can be chained round.

3rd—When it can be seen over, but neither chained over nor round.

(3) To find the intersection of two lines meeting in a lake or river, and the distance to the point of meeting.

(4) To find your place in a survey by observation from that position to certain fixed points on the survey—

1st—With prismatic compass.

2nd—With pocket sextant.

(5) Investigation of various methods of tracing curves—

(*a*) Without angular instruments—

By chords and offsets.

By offsets from a common tangent.

By successive bisection of arcs.

(*b*) With theodolite—

By angles at the circumference when the point of intersection of the tangents to the curve is accessible.

When the point of intersection is inaccessible.

By two theodolites at starting points of curve.

(*c*) Serpentine curves.

(6) Plotting chain survey.
(7) Plotting survey with chain and prismatic compass.
(8) Plotting theodolite traverse by Gale's method.
(9) Plotting level sections.
(10) Computation for the reduction of the base line.
(11) Reduction to the centre of angles taken from satellite stations.
(12) Calculation of the sides of the triangles in a trigonometrical survey.
(13) Calculation of the relative vertical heights of the stations as determined by theodolite.
(14) Equalising areas—
  (*a*) Of irregular polygons.
  (*b*) Of irregular offsets.
(15) Colouring of maps and surveys with the necessary printing of title and drawing of scales.
(16) Colouring of level-sections.
(17) Enlargement or reduction of plans by—
  (*a*) Pantograph.
  (*b*) Squares.
(18) Methods of entering the topographical details, horizontal and vertical styles.
(19) Conventional signs used in surveys and plans.

Practical Astronomy.

(1) Astronomical definitions.
(2) Determination of the true meridian—
  By equal altitudes of a star.
  By maximum elongation of a circumpolar star.
(3) Determination of latitude—
  By meridian altitude of the sun with sextant and artificial horizon.
  By circummeridian altitudes of a star with theodolite.
  By observations on Polaris.
(4) Approximate methods of determining the meridian and latitude without the use of angular instruments.
(5) Construction of horizontal sun-dials and method of graduating dial-plate.
(6) Simple methods of determining the longitude in which the use of the nautical almanac is not required.

Field Work.

First-year Class.

A small survey with chain only.
A more extensive survey (Botanic Gardens) with chain and prismatic compass.

A line of level about two miles long, the same to be carefully checked.

Ground tracing.

Second-year Class.

A line of levels about one mile long, the same being carefully checked.

A survey, about four square miles in area, by triangulation and traverse (Gale's), the details being filled in by plane-table.

Contouring. Laying out curves. Setting out half widths on side-long ground. Erection of profiles for embankments. Adjustments of instruments. Observations for determining the meridian and latitude.

Third-year Class.

Select a line of railway about five miles long; make a traverse along the same, filling in detailed plan by plane-table. Level over this line, and make the needful cross sections.

8.—DRAWING.

Construction of scales. Geometrical construction. Curves of arches, &c. Descriptive Geometry. Orthographic Projection: Of Planes: Of Solids, under given conditions. Sections of solids. Intersection of solids. Development of solids. Shadows. Isometrical Projection. Perspective. Machinery. Topographical drawing.

Work to be executed by Students.

1. Printing. 2. Scales. 3. Geometrical Figures. 4. Arches. 5. Problems in Descriptive Geometry. 6. Projections and Intersections of solids. 7. Intersections of Roofs. 8. Elevations, sections and plans of buildings and bridges from copies. 9. Ditto from rough sketches and dimensions. 10. Projections of shadows (simple cases). 11. Free-hand sketches—(*a*) from copies, (*b*) from models. 12. A drawing from actual measurement. 13. Machinery. 14. A simple isometric drawing. 15. A simple perspective drawing. 16. Maps, Sections, &c.

9.—PROJECT.

This will consist of the surveys and levels for a line of canal or railway, about 5 miles long, with cross sections of streams crossed, accompanied by designs for such iron and masonry structures that may be required for the streams or roads that are crossed. The whole to be supplemented by a book of calculations showing how the necessary dimensions have been arrived at.

The drawings that will accompany this project are—

(1) General plan of country showing adopted line.
(2) Longitudinal section of line.
(3) Design for a masonry bridge.
(4) Design for a plate girder bridge.
(5) Design for an open work bridge, such as a Warren, Lattice, or Bowstring girder.
(6) Such other designs as may be required to complete the project.

The designs will be got up in sufficient detail to enable the bridges, &c., to be ordered without further information.

10.—MATHEMATICS.

Algebra.

Addition, subtraction, multiplication and division of algebraical expressions (including fractions), highest common factor, lowest common multiple, involution, evolution, theory of indices, surds, simple and quadratic equations involving one or more unknown quantities. Theory of quadratic equations and quadratic expressions. Ratio, proportion, variation. Arithmetical, geometrical, and harmonical progressions. Mathematical induction, permutations and combinations. Binomial theorem, exponential theorem.

Trigonometry.

Direction of measurement of straight lines or angles denoted by algebraical sign. Measurement of angles by degrees and circular measure. Definition of the trigonometrical ratios and inverse trigonometrical functions. Investigation of formulæ, including all angles which have the same sine, cosine or tangent. Formulæ expressing the sine, cosine or tangent of the sum or difference of two angles in terms of the trigonometrical ratios of the single angles, with formulæ derived from these. Limiting values of simple trigonometrical functions of an evanescent angle. Sum of a series of sines or cosines of angles in arithmetical progression. Solution of triangles. Properties of triangles. Determination of unknown heights and distances.

Application of Logarithms.

Each candidate will be supplied with a book of mathematical tables, and required to extract all necessary information from the tables. Properties and use of logarithms. Numerical solution of triangles. Easy questions in algebra, trigonometry, mensuration, statics, dynamics, or hydrostatics, involving logarithmic calculation.

Mensuration.

The areas of plane figures, and the application of Simpson's rules. Areas of surfaces. Volumes of solids, including the application of the prismoidal formula

PLANE GEOMETRY (INCLUDING THE GEOMETRY OF CONICS).

Simple problems in the geometry of the straight line, triangle and circle, treated according to modern methods. The more important properties of the parabola ellipse and hyperbola section of a cone. Text-book, Wilson's Elementary Geometry and Conic Sections.

STATICS.

The composition and resolution forces, acting in one plane on a particle or rigid body. Moments. Bending moments. Conditions of equilibrium of a particle or rigid body acted on by forces in one plane. Force diagram of a system of forces in equilibrium. Meaning of virtual work and work done by a force. Applications of the above to the solution of problem (the candidate to be allowed the option of adopting the graphic method of solution). Equilibrium of constrained bodies and the simple machines. Determination of centroids. Friction.

DYNAMICS.

Kinematics.—Velocity and acceleration, uniform and variable. Angular velocity. Numerical value of velocity or acceleration dependent on units of time and space. Relative velocities and accelerations. Composition and resolution of velocities and accelerations. Formulæ connecting time and space described, velocity and acceleration.

Kinetics.—Newton's laws of motion. Units of mass, force and work. Relation between force, mass moved, and acceleration produced. Attwood's machine. Motion of projectiles in vacuo. Direct impact of bodies. Co-efficient of restitution. Constrained motion of bodies sliding down smooth curves. Formula (without proof) for the time of a small oscillation of a simple pendulum. Uniform motion in a circle. Conical pendulum. The principles of work and energy. Conservation of energy.

HYDROSTATICS.

Definition of a fluid, a liquid, a gas. Density and specific gravity of a substance and of a mixture of liquids or gases. Pressure at a point. Equality of pressure in all directions in a fluid. Transmission of fluid pressure. The hydrostatic press. Determination of pressure at any point in a homogeneous liquid. Whole pressure on a surface immersed in liquid. Resultant, horizontal and vertical pressure on an immersed surface. Centres of pressure of parallelograms, triangles, circles, or ellipses immersed in any manner in liquid. Conditions of equilibrium of floating bodies. Boyle's and Gay Lussac's laws for gases. The barometer, thermometer, siphon, common pump, air pump, and diving-bell. The atmosphere, pressure at any height in it. Determination of heights by the barometer. Hydrostatic balance. Hydrometers.

DIFFERENTIAL CALCULUS.

Definition of a differential co-efficient. Differential co-efficient of a sum, product, and quotient. Differential co-efficients of simple

functions. Successive differentiation. Leibnitz's theorem. Taylor's theorem. Maclaurin's theorem. Expansions of functions. Maxima and minima values of functions of one variable. Differential equation of the tangent and normal to a curve.

Integral Calculus.

Integration, a limiting form of summation. Integration of simple functions by parts and by substitution. Integration of rational fractions. Integration between definite limits of forms which are generally integrable.

CHEMISTRY.

I.—Pure Chemistry.—Physical properties of the metals used in the arts. Alloys. Behaviour of metals on being heated in contact with air. Investigation into the causes of alteration. Oxygen. Nitrogen. Composition of air. Hydrogen. Detonating mixture. Physical properties of non-metals. Allotropic modifications. Rapid, slow, and incomplete combustion. Oxides of carbon, sulphur, phosphorus, arsenic, silicon, boron. Metallic oxides. Combination of metals with sulphur. Sulphides of hydrogen and carbon. Preparation and properties of the halogens. Their compounds with hydrogen. Halogen salts. Conversion of oxides, sulphides, and chlorides into each other; roasting. Electrolysis of binary compounds. Displacement of one metal by another in binary compounds. Quantitative analysis of cuprous and cupric oxides. Synthesis and analysis of water. Analysis of the oxides of lead. Laws of definite proportions, of multiple proportions, and of relative atomic masses. Laws of combination by volume. Avogadro's law. Chemical notation. Quantivalence. Anhydrides; hydroxides; acids and bases. The more important oxy-acids. Formation of salts by the interaction of acids and bases. Salts, normal, acids, basic; anhydro-salts. Water of crystallisation and constitution. Formation of salts by the action of acids on oxides and metals. Double decomposition. Principles of alkalimetry and acidimetry. Reduction of oxy salts in solution by metals and by the electric current. Ozone. Hydrogendioxide. Oxides of nitrogen and chlorine; corresponding acids. Oxidising action of nitric, chromic, and permanganic acids; of chlorine, bromine, and hypochlorites. Hydrides of carbon (methane and ethylene), nitrogen, phosphorus, arsenic, antimony. Cyanogen; hydrocyanic acid. General methods of preparing oxides, hydroxides, chlorides, bromides, iodides, sulphates, nitrates, phosphates, carbonates. Solubility of salts; nature of solutions; mutual action of salts in solution; natural waters. The most important sources of the metals used in the arts. Determination of molecular formulas and atomic weights; vapour density; isomorphism; specific heat; depression of freezing point and vapour pressure. The periodic law.

II.—Chemical Energetics: A—Thermo-chemistry.—Object. Methods of investigation. Calorimeters for solutions and combustion. Thermochemical notation (Ostwald's). Thermal units. The fundamental laws of thermodynamics. Cycles. Relation between chemical

reactions and entropy. Allotropy. Hess' principle. Heat of combustion and formation; calculation of heat of formation. Neutralisation; behaviour of the more important mono-, di-, and tri-basic acids. Dissociation; typical examples; connection with temperature and pressure. Thermal changes attending solution and hydration. Exothermal and endothermal reactions. Application of the principles of Thermochemistry to the solution of technical problems.

B.—Photo-chemistry.—Actinometers; Bunsen and Roscoe's experiments. The laws of photo-chemical action. Photo-chemical induction. Contact effects. Assimilation of carbon by plants; storage of solar energy. Action of light on salts of silver, iron, chromium, uranium. Theory of photo-chemical action.

C.—Electro-chemistry.—Faraday's laws. Electro-chemical equivalents. Calculation of E.M.F. of galvanic elements. Differences of potential due to contact of metals and electrolytes. Electrolytic conduction; polarization.

III.—Chemical Technology.—Chlorine. Bromine. Iodine. Hydrochloric, sulphuric, nitric acids. Phosphorus. Coal gas. Caustic potash and caustic soda. Nitre. Pearl-ash. Potassium bichromate. Sodium. Common salt. Sodium carbonate: LeBlanc, ammonia process. Borax. Soluble glass. Quicklime. Portland cement. Bleaching powder. Plaster of Paris. Magnesium. Glass and porcelain. Alum. Blanc fixe; zinc white; white and red lead. Silver nitrate.

IV.—Practical Exercises.—Qualitative analysis of solutions containing K, Na, Mg, Ca, Sr, Ba, Zn, Ni, Co, Fe, Al, Cr, Cd, Cu, Hg, Pb, Bi, Sn, Sb, As, Au, Ag. Analysis of chlorides, sulphates, nitrates, nitrites, carbonates, phosphates and silicates. Quantitative analysis, brass, bronze, and bar silver. Determination of sulphur and phosphorus in iron ores. Determination of iron in iron ores and in samples of iron by volumetric analysis. Assaying of iron in the dry way. Determination of gold by Skey's process. Testing of drinking water for ammonia, lead and sodium chloride, colorimetric tests. Analysis of limestones.

PHYSICS.

I.—Heat.

Expansion; Ramsden, weight-thermometer; Pierre; Regnault's experiments on the absolute expansion of mercury and the expansion of gases. Charles' law. Principles of thermometry. Temperature as measured by the expansion of solids, liquids, and gases. Mercurial thermometer; air-thermometer. Thermometers for various purposes. Density of solids, liquids, and gases. Absolute temperature. Calorimetry. Specific heats of solids and liquids; method of mixture, Regnault; Bunsen's ice-calorimeter. Specific heat of gases—at constant pressure, Regnault; at constant volume, Rontgen. Dulon and Petit's law; Neumann's law modified by Regnault. Changes of state of aggregation. Regelation. Critical temperature; Andrew's experiments. Measurement of heat of fusion and vaporization. Influence of pressure

on melting and boiling-point. Methods of liquefying gases. Maximum pressure of vapours; Dalton, Regnault; pressure of saturated steam below and above 100° C. Vapour densities; Hoffman's, V. Meyer's methods. Hygrometry; Regnault's hygrometer; psychrometer. Conduction; variable and permanent stages. Simple cases of steady flow across a plate and along a bar; Wiedemann and Franz' experiments. Convection. Joule's determination of the mechanical equivalent of heat.

II.—Statical Electricity.

Electrification by friction. Betz' and Ayrton's electroscope. Ice-pail experiment. Induction. Ramsden's machine. Electrophorus. Voss' and Wimshurst's influence machines. Electric work and energy. Indicator diagram of electric work. Exploration of electric field. Potential at any point of the field. Lines and tubes of force. Equipotential surfaces; lines of induction. Method of drawing lines of force and equipotential surface. Measurement of electricity; torsion balance; attracted disc electrometer; quadrant electrometer Dimensions. Electrostatic units. Capacity. Condensers; electrification of two concentric spheres; Leyden jar, Lodge's hydraulic model. Specific inductive capacity. Absolute measurement of capacity; statical comparison of capacities; measurement of specific inductive capacity; standard air condenser.

III.—Current Electricity.

Chemical and thermal methods of producing currents; Daniell, Grove, Bunsen, Leclanche, Meidinger, Smee; thermopile; thermo-electric battery. Pyro-electricity. Classification of bodies as regards transference of electricity. Electrolytic conduction. Electrolysis of fused compounds and of saline solutions. Faraday's laws. The voltameter. Metallic conduction. Ohm's law. Kirchhoff's laws. Units of resistance. Poggendorff's rheochord. Resistance coils. Wheatstone's bridge. Resistance of battery. Resistance of galvanometer; Thomson. Electromotive force. Standard cells—Raoult, Lodge, Latimer Clark. Determination of electromotive force; statical method; Fechner's and Ohm's methods; Poggendorff's compensation method. Relation of electricity to heat; Joule's law; Lenz' experiments. Gaseous conduction. Disruptive discharge. Currents regarded as moving charges; Rowland's experiments. Flow of electricity and flow of electric energy; outlines of Poynting's theory. Phenomena attendant on the starting, stopping, and varying of a current. Oscillating discharges.

IV.—Magnetism.

Fundamental experiments. Magnetic field. The earth a magnet; magnetic elements; declination theodolite; dip-circle; bifilar magnetometer. Methods of magnetization. Relation of magnetism to electricity. Oersted's experiment. Tangent and sine-galvanometer; Thomson's reflecting galvanometer; Wiedemann's two-coil galvanometer. Electrodynamic experiments; the solenoid. Solenoidal magnet

and magnetic shells. Electromagnets; types. Permeability and methods of measuring it; its relation to temperature and mechanical stress; critical temperature, its relation to other physical properties. Magnetic hysteresis. Magnetic flux, magneto-motive force, reluctance. The law of traction. Induction of currents; Lenz' law. Direction of induced currents specified by reference to lines of magnetic force. Movement of lines of force with change of magnetization. Self-induction. Ruhmkorff's coil. Electromagnetic units. Theories of magnetism.

V.—Radiant Energy.

Laws of a vibrating particle. Harmonic vibrations. Transverse and longitudinal waves. Interference of waves travelling in the same and in opposite directions Stationary waves. Composition of undulations; elliptical, circular, and rectilinear vibrations. Huyghen's principle. Reflection and refraction of thermal, luminous, and electric waves. Velocity of propagation; Foucault's and Fizeau's experiments. Plane, spherical, and paraboloic mirrors. Single and double refraction. Prisms and lenses. Minimum deviation. Determination of refractive indices of solids and liquids. Melloni's experiments on radiant heat. Hertz' experiments on electric radiations. Outlines of Maxwell's theory of light. Dispersion. Spectroscope and spectra. Conditions of achromatism. Absorption of ætherial waves: diathermancy and athermancy; coloured bodies.

VI.—Applied Physics.

1. *Heat.*—Pyrometers: Wilson, Siemens, LeChatelier. The double acting steam engine. Ice-making machines. Otto's gas-engine Petroleum engines.

2. *Light.*—The sextant. Photometry; Ayrton's dispersion photometer. Telescopes. Microscopes. The camera obscura; principles of photography.

3. *Electricity and magnetism.*—Electro-metallurgy, Telegraphy and Telephony. Batteries in common use. Signals. Single needle instrument; sounder; Siemens' ink-writer; Siemens' A. B. C; relative merits. Siemens' relay. Line current, local current, double current working, translation. Duplex telegraphy; differential and bridge principle. Overground lines; supports, their preservation; insulators. Faults: in instruments; on line; total, partial, intermittent. Testing; Wheatstone's bridge; localising faults; loop test. Lightning conductors. Terminals, single and multiple points; earth connection, its importance; the conductor proper: material, form; joints; clips and brackets; ridge circuits; incidental connections, gas and water pipes; space protected; protection of dwelling-houses, magazines, chimneys; periodical inspection and testing; older and modern theories. The telephone and microphone. Electric bells and indicators. Dynamo-electric machinery. S. Thompson's definition of dynamo. The ideal simple dynamo and motor; connection between counter-electromotive force and maximum work. Efficiency. Causes of loss of energy. Types of armatures; armature coils and cores. Field magnets. Pole-pieces. Field magnet coils. Commutators, Collecting

brushes, brush-holders. Curves of potentials and induction. Reaction of armature and field. Lead of brushes; angle of lead. Methods of exciting field magnets. Classification of dynamos. Examples. Dynamos of class I; closed coil armatures: gramme for large currents, Victoria dynamo; open-coil armature: Brush. Dynamos of class II: alternate current dynamo. Dynamos of class III. Characteristics.

Transmission of electric energy. Accumulators. Transformers. Air-lines; insulators, testing; modes of attaching the wire; material for wires; joints; lightning protectors. Underground conduits; the three-wire system, lead covered cables. Comparison with other methods of transmitting energy.

Motors. Appliances: electric pumping plant, electric tramways, telpher lines, electric mining machinery.

Electric lighting. The Brush lamp. Incandescent lamps. Electric welding. Electric measurements and measuring apparatus. The volt and Ampère. Ayrton's sulphuric acid voltameter. Calibration of galvanometers. Methods of shielding galvanometers. Proportional galvanometers. Ampère-meters and volt-meters. Ampère-balances. The ballistic galvanometers. Permanent magnet meters: Ayrton's. Spring meters: Siemen's electro-dynamometer, Ayrton's magnifying spring ammeter. Gravity control-meters. Electro-magnetic control-meters. Relative merits; testing for accuracy; calibration by the calorimetric and the voltameter methods. Cardew's voltameter. The Ohm; resistance coils; the shunt-box. Commercial Ohmmeters. The Farad and micro-farad. The Watt.

METALLURGY.

Physical properties of metals; testing machines; influence of impurities on the properties of iron and copper.

Alloys.—Effect of temperature changes on metals and alloys, with special reference to steel; annealing, hardening, tempering.

Fuel.—Classification; manufacture of coke; Wilson's gas producer; water gas; absolute, specific, and pyrometric heating power; assay of coal; Wright's calorimeter.

Materials.—Ores; fluxes; slags; oxidising and reducing agents; calculation of furnace charges.

Furnaces.—Hearths for roasting and refining and liquation; shaft furnaces; iron blast furnace, Rachette, Pilz, cupola, reverberatory furnaces, puddling-furnace, furnaces used in the smelting for copper and tin, cupellation, closed-vessel furnaces, Deville's blast furnace, furnaces used in the reduction of blende and cinnabar and in the manufacture of cement steel, the converter. Means of supplying air chimneys, blowing engines, Cowper's and Whitwell's stoves.

Metallurgical processes.—Classification, outline of typical processes. Blast-furnace process; puddling; Dank's furnace; Siemens' open hearth; Siemens-Martin; Bessemer; basic process; Darby's recarburisation process; tungsten steel, mitis metal. The Idria process. Hähner's furnace. Tin smelting. Extraction of zinc by the Belgian and Silesian methods. Héroult's aluminium process. Welsh process of extracting

copper from copper pyrite. Lead smelting, Flintshire. Extraction of silver from lead, Parkes, Pattinson, cupellation, concentration of gold in batteries, modern pan amalgamation. Augustin's wet process as practised in America; Plattner's chlorine process. Methods of producing sound castings.

General considerations.—Capital and labour; causes of failure; prices of metals.

GEOLOGY.

Object of geology.—Its relation to other sciences. The doctrine of uniformity; its limits.

I. *Astronomical Geology.*—Information obtained from meteorites and by the spectroscope. The nebular theory. Origin of internal heat. Climate in its geological relations; glacial and mild periods; Croll's theory modified by Wallace.

II. *Geognosy.*—The globe and its envelopes. Shape and nature of globe; density; probable internal condition; evidences of pressure and internal heat; isogeothermal surfaces. The age of the earth's crust; Tait's and Wallace's views. Persistence of continental ridges and abysmal depressions. *Petrography.* Microscopic character of rocks. Microscopic elements; their importance for the study of the history of rocks. Microscopic character of quartz, orthoclase, plagioclase, augite, hornblende, calcite. Essential and accessory constituents. Classification of rocks. Microscopic characters and essential constituents of the following rocks: limestone, dolomite, quartzite, flint, jasper, hornstone; amphibolite; gneiss, micaceous and chloritic schists, phyllite; granite; quartzporphyry; syenite, trachyte, phonolite, obsidian, pumice; diorite; diabase, dolerite, plagioclase-basalt; sand and gravel, sandstones, conglomerates, breccias, shale, clay; laterites; tuffs; shell-marl, coral-limestone, chalk, crinoidal limestone; tripolite, flint; guano; peat, lignite, coal, anthracite, graphite, oil-shale, petroleum, asphalt; bog iron ore, clay-ironstone.

III. *Dynamical Geology.*—Volcanic phenomena; description of volcanoes—kind, shape, distribution, relation to lines of weak resistance and instability. Theories of vulcanicity. Hot springs. Earthquakes. Secular upheaval and depression. Geological functions of air. Geological functions of water and ice; chemical and mechanical action; denudation and deposition; river valleys; peculiarities of Indian rivers; glacial erosion; formation of lakes. Geological functions of plants and animals; coral islands; Darwin's and Murray's theories.

IV. *Petrogenetic Geology.*—Origin of granite, syenite, diabase, diorite, and basalt. Origin of sedimentary rocks; minerogen, phytogen, and zoogen sedimentary rocks; theories on the origin of coal-beds; origin of laterite. Origin of metamorphic rocks; theories of metamorphism; local and regional metamorphism; origin of rock-cleavage. Ore deposits; origin and classification.

V. *Architectonic Geology.*—Forms of bedding. Surface markings. Concretions. Relative persistence of strata. Overlap. Groups of

*strata. Joints. Strike and dip; outcrop. Monocline, syncline, anti*cline. Faults, origin and kinds. Intrusive phase of eruptivity; bosses, sheets, veins and dykes, necks. Interbedded phase of eruptivity; lavas tuffs. Unconformability.

VI. *Palæontological Geology.*—Object. Conditions for the entombment of organic remains. Preservation of organic remains in mineral, masses; fossilization. Uses of fossils in geology.

VII. *Historical Geology.*—Leading principles in stratigraphy. Equivalent strata; absent strata and formations. *Indian Geology.* Peninsular area. The metamorphic series. The transition series. Lower and Upper Vindhyans; petrology; Vindhyan basin. The Gondwána system; geological position and characters; probable fluviatile origin; relation of Gondwána basins to existing valleys; lower and upper groups; Tálchir—Karhárbari; Barákar, ironstone shales; Rániganj, Rajmahál, the most important coal-fields. The Deccan trap series; area and petrology. Laterite; distribution, age. Post tertiary and recent formations; older river gravels and clays; kankar. Indo-Gangetic plain; upland and alluvial soils; red soil, regur, peat. General outlines of the geology of the Himalayan area.

VIII. *Physiographical Geology.*—Terrestrial features due to disturbance of crust; monoclinal, symmetrical, unsymmetrical, reversed flexures; alpine type of mountain structure. Features due to volcanic action; the Deccan trap area. Features due to erosion; Indian examples.

IX. *Field Geology.*—Geological surveying; instruments; tracing of boundaries and faults. Sections; how to find direction and amount of dip; Dalton's construction; clinometer. Levelling; surface profile, datum level, bench-marks, methods of geological levelling, Abney's level. Lithology; practical exercises in the identification of Indian rocks.

MINERALOGY.

Province of mineralogy. Its relation to other sciences.

I. Properties of Crystals independent of direction.

Density and specific gravity. Methods of determining specific gravities; hydrostatic balance; pycnometer; Jolly's balance; floatation methods.—Thoulet's, Klein's, Retger's solutions. Separation of rock-forming minerals by the floatation method.

II. Physical Crystallography.

Elasticity. Relation of co-efficient of elasticity to direction. Surfaces of elasticity. Method of determining co-efficients of elasticity in crystals. Classification of crystals with reference to elasticity. Physical definition of "crystal."

Cohesion. Cleavage. Fracture. Hardness: Mohs' scale. Corrosion figures.

Optical properties of minerals. Kind and degree of lustre. Double refraction and polarization. Nicol's prism. Classification of crystals according to their optical properties. Uniaxial and biaxial crystals.

Examination of crystals in parallel and convergent polarized light; polarization microscope. Circular polarization. Absorption of light; ideochromatic and allochromatic minerals; pleochroism, Haidinger's dichroscope, microscope with one nicol; distinction between augite and hornblende.

Thermal properties. Good and bad conductors; conductivity of single and double refracting crystals; expansion.

Electrical properties. Good and bad conductors; pyro-, actino-, and piezo-electricity.

Magnetic properties. Para- and diamagnetic minerals. Separation of rock-constituents by the electro-magnet.

III. Geometrical Crystallography.

Relation of physical properties to geometrical form; arrangement of molecules. Crystalline form; faces. Planes of reference; axes, parameters; indices; symbols. Law of rationality of indices, its independence of temperature. Principles of Miller's, Weiss', Nauman's notation. Fundamental form; its selection. Zones; tautozonal faces; zonal axis; law of conservation of zones. Symmetry; planes and axes of symmetry; principal and common planes. Classification of crystals. Fundamental law of physical crystallography. The six crystallographic systems characterized with reference to planes of symmetry. Simple forms and combinations. The holohedral forms of the regular system as modifications of the hexakisoctahedron. Combinations of hexahedron, octahedron, and rhombic dodecahedron. The holodedral forms of the remaining five systems. Closed and open forms; prismatic, tabular and pyramidal habit. Nature of hemihedrism. Tetrahedral, pentagonal, and plagihedral hemihedrism in the regular system. Rhombic resp, sphenoidal, pyramidal, and trapezohedral hemihedrism in the hexagonal and tetragonal systems. Sphenoidal hemihedrism in the rhombic system. Hemihedrism impossible in the monosymmetric and asymmetric systems. The nature of Tetartohedrism. Trapezohedral tetartohedrism in the hexagonal system; quartz. Apparently holohedral forms differ from real ones—loss of symmetry by combination with particular hemihedral forms, corrosion figures, circular polarization. Hemimorphism—tourmaline, hemimorphite. Crystallographic mimicry-leucite, sal-ammonia. Groth's method of deducing hemihedral and tetartohedral from holohedral forms. Isomorphism and heteromorphism. Isomorphous groups of elements. Iso-heteromorphous series of the calcite-arragonite group, of the augite-hornblende group, and of the felspars. Morphotropism and Isogonism. Hemitrophy. Twinning plane, twinning-axis, composition plane. Twins with parallel and non-parallel axes. Contact-twins and penetration twins. Distinctive features of hemitropes. Polysynthetic crystals. Twin striation and combination striation. Crystalline aggregates, druses. Pseudomorphism. Pseudomorphs by incrustation, substitution, and alteration; paramorphs. Measurement of angles; contact and reflecting goniometers; relative merits.

IV. Chemical Mineralogy. Calculation of formula. Groth's classification of minerals. Group tests.

V. Descriptive Mineralogy. A somewhat detailed description of the following minerals—

Elements: diamond, graphite, sulphur, bismuth, copper, silver, gold, platinum. *Sulphides:* pyrite, marcasite, arsenopyrite; leucopyrite; pyrrhotite; galena, chalcosite, sphalerite, argentite, cinnabarite; antimonite; chalcopyrite, bornite.

Sulphosalts: pyrargyrite, proustite, tetrahedrite, stephanite. *Oxides:* cuprite; zinkite; corundum, hematite, menaccanite; spinel, franklinite, magnetite, chromite; quartz, cassiterite, pyrolusite; geothite; limonite. *Oxysalts:* (*a*) carbonates—calcite, dolomite, magnesite, siderite, smithsonite; aragonite, witherite, strontianite, cerussite; azurite; malachite; (*b*) sulphates—anhydrite, barite; gypsum; (*c*) phosphates—apatite; (*d*) silicates—tourmaline; epidote; olivine; calamine; garnet; leucite, nephesite; muscovite, brotite, lithionite; prochlorite, rhipidolite; talc, serpentine; apophyllite stilbite, heulandite; hypersthene pyroxene, amphibol; orthoclase, microcline, albite, indianite, oligoclase-labradorite; kaolinite. *Haloid salts:* sylvite, halite, cerargyrite, fluorite; cryolite.

VI. Practical Exercises. Determination of specific gravities. Use of the scale of hardness. Exercises at the polarization microscope. Measurement of angles by the aid of contact and reflecting goniometers. Blowpipe analysis. Identification of Indian minerals by the aid of Brush's 'Manual of Determinative Mineralogy.'

APPENDIX A.

Course of Study for the Engineer Department.

	First year, A* & B†.	Second year, A & B.	Third year, A & B.	Fourth year, A.	Fourth year, B.
	1	2	3	4	5
Mathematics ...	Algebra, Euclid, Trigonometry, and Mensuration.	Statics, Dynamics, Geometrical Conic Sections.	Analytical Geometry, Differential Calculus, Elements of Integral Calculus.	Integral Calculus, Hydrostatics.	Integral Calculus, Hydrostatics.
Natural Science	Chemistry ...	Physics (or Chemistry)	Applied Physics and Chemistry.	Geology, Metallurgy, and Mineralogy.	Practical Chemistry.
Engineering ...	Field-work ...	Building materials, brick and stone, masonry, earthwork, carpentry, foundations, roads, estimating masonry structures, direct stresses in building materials, surveying.	Construction of walls, floors, and roofs, railroads, irrigation works, arching, retaining walls, stresses in roof trusses, estimating iron structures, mechanism, surveying.	Iron bridge construction, transverse stress, deflection stresses in girder bridges and suspension bridges, torsion, hydraulics, steam-engine, architecture, preparation of civil engineering project.	Transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, steam-engine, workshop appliances, machine designs, preparation of mechanical designs.
Drawing ...	Printing, geometrical and orthographic projections, scales.	Isometrical, topographical, and free-hand drawing.	Perspective, topographical, free-hand, architectural, and machine drawing.	Mechanical, topographical, and free-hand drawing.	Machine-drawing, free-hand-drawing.

* Civil Engineering. † Mechanical Engineering.

APPENDIX B.

Certificate of Attendance of ——————————, *a student of the Engineering Department of the Civil Engineering College, Sibpur.*

CERTIFIED that —————————— attended the lectures in the Sibpur Civil Engineering College for ——— sessions from ——— to ——— At the University Examination in Engineering held in ———— he passed in the ————Division.

He has spent time in the shops as follows :—

Time spent in each.	Months.	Proficiency.
Carpenters' shop ...		
Blacksmiths' „ ...		
Moulders' „ ...		
Fitters' „ ...		

He has completed his practical course to the satisfaction of the authorities of the College.

SIBPUR,
The 189 . } *Principal, Civil Engineering College.*

ENGINEER DEPARTMENT.

WORKSHOP COURSE.

Workshop hours ... 1 P.M. till 3-30 P.M. daily, except Saturdays.

First Year.

Carpenters' shop.—A complete course in the use of carpenters' and joiners' tools. The students are required to make ordinary joints, stools, boxes, doors, windows, tables, trusses, and the usual framings required in engineering works. Their proficiency in this branch of their practical training is tested at the end of their first year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

Second Year.

Blacksmiths' and Boiler-makers' shop.—The course in this shop comprises the using and handling of the different tools; laying and managing the fires; drawing down, bending, jumping, welding, splitting, punching, chamfering and tempering. The students are required to make small forgings of tools, bolts, nuts, hooks, shackles, parts of roof trusses, and machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose. Their proficiency is tested at the end of the year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

Third Year.

Vicemen and Fitters' shop.—The course in this shop consists of chipping, filing, and fitting to enable the students to gain experience in the tools used by this class of workmen, after which they make up various tools required in the Fitters' shop, and assist in ordinary fitting work. Their practical skill in this shop is not tested by examination, but in lieu of this they are required to keep note-books in which they sketch to scale the various details of the common machines in the shops, and are expected to be familiar with the working of all machines in the shop.

ENGINEER DEPARTMENT.

ANNUAL EXAMINATION, 1896.

MAY.

ARITHMETIC AND ALGEBRA.

1st and 2nd years.

1. Simplify $\frac{1}{16}$ of $(\frac{1}{10}-\frac{1}{11})+\frac{\frac{1}{7}-\frac{1}{9}\div(\frac{1}{9}+\frac{1}{11})}{(\frac{1}{7}+\frac{1}{9})\div(\frac{1}{9}-\frac{1}{11})}\times\frac{\frac{2}{3}+\frac{1}{7}\div(\frac{1}{7}-\frac{1}{9})}{(\frac{2}{3}+\frac{1}{7})+\frac{3}{7}-\frac{4}{9}}$.

Calculate to four places of decimals $\frac{(11\cdot29+1\cdot306+\cdot0009)\text{ of }(4\cdot13+\cdot6)}{(5\cdot23+7\cdot98)\text{ of }(3\cdot1+6\cdot283)}$

2. A gas meter after being used for 96 days registers 11,280 cubic feet as the consumption. The meter is then tested and found to register 17·5% in excess of the gas actually consumed. Find the amount that ought to be charged at 3*s.* 9*d.* per 1,000 cubic feet, and the average cost per night.

3. A person buys 20 shares at £28 15*s.* per share and receives interest at £1 10*s.* per annum on each share. To make this investment he sells out £500 stock bearing 5% interest at 82, and takes the remainder from a deposit account which pays 4%. How is his income affected by the change?

4. (*a*) Extract the square root of $x^4-4x^3+2x^2+4x-4x^1+x^0$

(*b*) Simplify $\frac{(7-2\sqrt{5})\ (5+\sqrt{7})\ (31+13\sqrt{5})}{(6-2\sqrt{7})\ (3+\sqrt{5})\ (11+4\sqrt{7})}$

5. Solve the equations:—

(*a*) $\frac{2x-1}{x-1}+\frac{3x-1}{x+2}=4+\frac{x-7}{x-1}$

(*b*) $\frac{x^2+2}{x^2+4x+1}+\frac{x^2+4x+1}{x^2+2}=\frac{5}{2}$

(*c*) $x^2-yz=ax$
$y^2-zx=by$
$z^2-xy=cz$

6. Define ratio and proportion. Find $a : b : c$ having given $\frac{b}{a+b}=\frac{a+c-b}{b+c-a}=\frac{a+b+c}{2a+b+2c}$

7. Show how to insert n means in geometric progression between any two quantities a and b.

If a, b, c, be in A.P., and a^2, b^2, c^2, be in H.P., prove that $-\frac{a}{2}$, b, c are in G.P., or else $a=b=c$.

8. Expand $(1-ax^3)^{-\frac{1}{3}}$ to four terms, and find the general terms.

9. Find the numerical values of the common logarithms of 7, 11, and 13; given $\mu. = \cdot 434294$, $\log_{10} 2 = \cdot 30103$.

10. If α and β are the roots of $x^2-px+q=0$, show that $\log_e (1+px+qx^2) = (\alpha+\beta)x - \frac{\alpha^2+\beta^2}{2}x^2 + \frac{\alpha^3+\beta^3}{3}x^3$.

GEOMETRY.

1st and 2nd years.

1. Show that the angles at the base of an isosceles triangle are equal to one another; and if the equal sides be produced the angles on the other side of the base are equal.

2. Given the base and the sum of the two sides of a triangle, find the locus of the foot of the perpendicular from either end of the base on the bisector of the external vertical angle.

3. In any triangle the square on the side opposite an acute angle is less than the squares on the sides containing that angle by twice the rectangle contained by either of these sides and the straight line intercepted between the perpendicular let fall on it from the opposite angle and the acute angle.

4. If P be the orthocentre of the triangle ABC, show that the sum of the rectangles AP. BC, BP. CA, CP. AB is equal to four times the area of the triangle ABC.

5. If two chords of a circle intersect in a point inside the circle the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.

6. One vertex of a rectangle turns round a fixed point, and the two adjacent vertices move along a given circle. Find the locus of the remaining vertex.

7. Inscribe a circle in a given equilateral and equiangular pentagon.

8. Given a straight line and two points on the same side of it, find a point in the given straight line at which the line joining the two given points shall subtend a maximum angle.

9. Construct a rectilineal figure similar to one given rectilineal figure and equal to another.

10. A centre of similitude of two circles is joined with the point of contact of one of the circles with either common tangent through the other centre of similitude. Prove that the line joining the middle points of the line so drawn and the centre of the circle bisects that common tangent.

Trigonometry and Mensuration.

1st and 2nd years.

1. Find from definition the sines of the angles 210°, 300°, 420°, 315°.

2. Express the trigonometrical relations in terms of the tangent.

3. Prove $\sin (A + B) = \sin A \cos B + \cos A \sin B$

$\cos A + \cos B = 2 \cos \frac{1}{2} (A + B) \cos \frac{1}{2} (A - B)$

$\cos 2A = \frac{1 - \tan^2 A}{1 + \tan^2 A}$

and express cos 5A in terms of cos A and powers of cos A.

4. (1) show that $\frac{\sec^2 \frac{A}{2}}{(a + b) + (a - b) \tan^2 \frac{A}{2}} = \frac{1}{a + b \cos A}$.

(2) A B C is a triangle. C P is drawn dividing the angle C into two parts α and β and the base A B into two parts A P, P B in the ratio m to n; prove that $(m + n) \cot \theta = m \cot \alpha - n \cot \beta = n \cot A - m \cot B$, where θ is the angle C P B.

5. In any triangle $\frac{b - c}{b + c} \cot \frac{A}{2} = \tan \frac{B - C}{2}$ and $a \sin (B - C) + b \sin (C - A) + c \sin (A - B) = 0$.

6. On a slope inclined at an angle to the horizon of 18° 34′ is a vertical tower. At 230 feet from the bottom of the slope the top of the tower makes an angle of 20° 15′ with the horizon and at the bottom of the slope an angle of 32° 27′ 48.″ What is the height of the tower?

7. Assuming Demoivre's Theorem expand cos x in powers of x.

Why do only even powers occur in the result and only odd powers in the corresponding expansion of the sine?

8. The sides of a triangle are 32, 27, and 48 inches. Find the area of the triangle and the diameter of the circumscribing circle.

9. A window is 5 feet high and 3 feet wide. The outer frame is of wood, 3″ × 3″ section. In its centre there is a circular ring one foot in diameter, made of wood $\frac{3}{4}$″ × $\frac{3}{4}$″ section. This is connected to the outer frame by four pieces of wood, 1″ × 1″ section, passing one from each end of two diameters at right angles to each other to the middle of a side of the frame. The spaces are filled in with glass. Find the cost of 20 of these windows, if wood cost Rs. 2-8 per cubic foot and glass 3 annas per square foot.

10 The frustum of a right circular cone is made of iron. Its height is 15″, the diameter of its smaller face is 9″ and of its larger 16″. Two conical holes are bored from each plane face. The diameters of the bases of these holes are each half the diameter of the corresponding

face, their axes coincide with the axis of the frustum, and their vertices meet at the middle point of the axis. The holes are filled with lead. Find the weight of the whole, if the specific gravity of iron is 7·8 and of lead 11·4.

MECHANICS.

2nd year.

1. Prove that a couple may be replaced by any other couple in the same plane, having the same moment. If the inner pressure on a lock gate be 4,500lbs acting at a point 2 feet from the bottom, and the outer pressure be 500 acting at 8 inches from the bottom, find the magnitude and point of action of the resultant pressure.

2. Show that the centre of gravity of a uniform triangular plate coincides with the centre of gravity of three equal weights, one at each corner.

Three uniform rods of the same materials, 34, 34 and 60 inches long, are formed into a triangle. Find their centre of gravity.

3. If three forces keep a body in equilibrium, they are either parallel or their directions meet in a point. The side C B of an uniform equilateral plate is vertical with C above B. It weighs 5lbs. It is hinged at A, and BC rests against a smooth peg at C. Find the reaction at C and the magnitude and direction of the reaction at the hinge.

4. Find the mechanical advantage in the third system of pulleys. Illustrate the principle of Virtual work by means of this system.

5. Show how to find graphically the magnitude, direction, and line of action of any number of co-planar forces acting on a body.

6. State and prove the parallelogram of velocities. A stone is thrown with a velocity of 66 feet per second from a train going at the rate of 60 miles per hour at right angles to the train. It hits a tree 90 feet from the line of rails, which are supposed straight. How far was the tree from the part of the train from which the stone was thrown at the instant it was thrown?

7. What do you mean by the term impulse, and how is it measured?

A shot of 1,800lbs. left a gun with a muzzle velocity of 1,600 feet per second. Find the impulse on the shot and the uniform force which acting on the base of the shot within the bore of the gun, 40 feet long, would have produced the same effect.

8. A particle is projected with a given velocity in a given direction. Find how high it will rise, the time taken in rising, and the range on the horizontal plane through the point of projection.

9. Define simple harmonic motion. Prove that in simple harmonic motion that the acceleration varies as the displacement, and that the periodic time $T = 2\pi/\sqrt{\mu}$. Show that the dimensions of this equation are correct.

10. Prove from the principle of energy $v^2 = u^2 + 2fs$., and that the velocity acquired by a particle in falling down a smooth curve is the same as would be acquired in falling vertically through the height of the highest above the lowest point of the curve. An engine raises in 40 seconds, by means of a wire rope weighing 6lbs. per yard, from a mine 275 feet deep, a cage weighing 4 cwt. containing 14 cwt. of coals. Find the horse power of the engine.

Engineering.

2nd year.

1. Give the practical classification of the following stones. State their composition and name the localities in which they are found in Bengal:—(*a*) Slate. (*b*) Trap. (*c*) Sandstone. (*d*) Marble. (*e*) Granite.

2. Describe how the manufacture of lime from kunkur is usually carried out on a small scale.

3. How are limes and cements usually classified as regards their setting properties? State the proportion of sand or surkhi you would specify to be used in a mortar made from each.

4. Describe with a skeleton sketch how bricks are burnt in Mr. Bull's Trench Kiln; explaining how the firing is controlled and also the gradual drying of the bricks.

5. How would you carry out comparative tests as to the suitability of various kinds of bricks for building purposes?

6. What are the chief causes of decay in timber and what are the best means of guarding against it? Give an example.

7. What do you know of—

(*a*) The manufacture of double shear steel;
(*b*) Case hardening;
(*c*) Chilled castings?

8. Describe briefly the manufacture of steel by the basic process.

9. Give a sketch of an Iron King Post Truss, showing how the roof covering is fixed.

10. Give a detailed sketch showing the construction and framing of one of the following:—

(*a*) An ordinary panel door,
(*b*) An ordinary sash door.

Nine questions only to be attempted.

Drawing.

1st and 2nd years.

1st year, questions 1, 2, 3, 4, 5 and 7. 2nd year, questions 1, 2, 3, 4, 6, 7 and 8.

1. Draw the outline of an elliptical arch of 24′ span and 6′ height on the scale of 1″=6′.

2. Find approximately the developed length of the semi-ellipse in 1 and represent it by a line on the scale $\frac{5}{16}$″=6′. Describe your method briefly and justify it.

3. Construct a circular scale of 90° to show each 10° and apply to it a vernier scale to read directly in degrees.

4. What is the scale of chords, and when is it to be used in preference to the protractor?

5. Draw a plan and elevation of an elbow, arms at 90°, in a circular zinc pipe of 2″ internal diameter, thickness of material $\frac{1}{32}$″.

6. Give plan and elevation of an elbow of the same dimensions as in 5, but with arms placed at 60°, and the axis of one arm making an angle of 30° with the V.P. and 60° with the H.P.

7. A sphere of 1″ radius is cut by a plane at $\frac{1}{2}$″ from its centre and making an angle of 30° with the ground plane. Draw the plan of the larger segment of a sphere of double the surface area and similarly cut, by construction only.

8. Give an isometric projection of a triangular wooden frame, made of 2″ by 1″ stuff, one side to be 3′ long and making angles of 50° with each of the other sides. Scale 1″=1′ for the 3′ side; joints need not be shown in detail.

SURVEYING.

1st year.

Seven questions only to be attempted.

1. Explain the method of taking angular measurements by means of the prismatic compass. Distinguish between a bearing and an angle by means of the angular measurements taken at any one station in a survey.

2. Describe the permanent adjustments of the dumpy level.

3. How would you set off a chain line accurately at right angles to a straight wall without the aid of angular instruments?

4. Describe any two methods of obtaining a copy of a map on a reduced scale, noting clearly the essential points of each method.

5. (*a*) In a chain line of 2 miles length, to what degree of accuracy should the chainage be taken in the field if the results are to be plotted on a piece of paper 24 inches long?

   (*b*) How would you find the true length of your chain and correct your measurements for the chain error?

6. Construct (*a*) a diagonal scale of inches to read to $\frac{1}{24}$″,

   a scale of $\frac{1}{2500}$ to measure feet.

7. Construct a circular vernier scale to read to minutes, the circle scale showing ¼ degrees.

8. Find the acreage of the circuit A B C D E, plotted on the scale of 50 yards = 1 inch. See Fig. 1, Plate I.

SURVEYING.

2nd year.

1. Give a neat sketch showing the construction of an ordinary dumpy level.

2. (*a*) Construct a diagonal scale of $\frac{1}{2\,1\,0}$ to show feet only.

(*b*) Construct the scale on which ¾ of a mile is represented by $2\frac{1}{4}$ inches. Subdivide it to show distances of 100 paces (of 30 inches each), and mark off the distance representing of 3,000 paces.

(*c*) If your survey is to be plotted to a scale of $\frac{1}{1\,0\,0}$, to what degree of accuracy should you take your chainage measurements in the field?

3. Explain the filling up of a Gale's traverse table, and state how you may calculate the area enclosed.

4. How can you find your position in a plane table survey when 3 or more station points are visible without the assistance of a chain or tape?

5. Fill in a page of an imaginary level book with exactly 12 readings, showing the instrument to have been moved twice from first position. Give arithmetical checks.

6. How would you contour—

(*a*) a large area in a hilly country;

(*b*) a large area in a level country like Lower Bengal?

7 Describe fully all the consecutive operations performed in taking a theodolite out of its box and observing a series of horizontal angles at a trigonometrical station.

8. How do you perform the permanent adjustments of Cooke's patent reversable level?

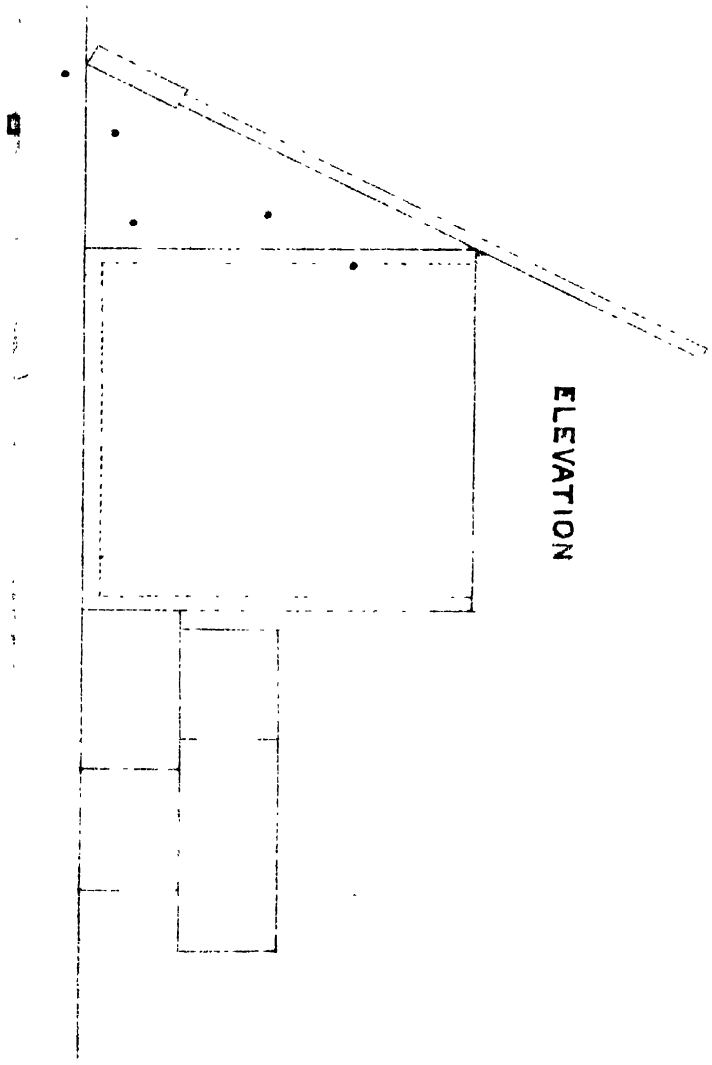
9. How can you find—

(*a*) The height of an inaccessible object situated on a level plain, using a pocket sextant and a chain?

(*b*) The distance of an inaccessible point, using a chain only?

10. Show how an irregular six-sided figure may be reduced to a tiangle of equal area.

PLATE. I.



ELEVATION

CHEMISTRY.

1st year.

1. How has the atomic weight of chlorine been determined with and without reference to the relative densities of hydrogen and chlorine and their combining volumes?

2. Explain the reasons which have led chemists to assign to sulphuric acid the formula H_2SO_4, and to chloric acid the formula $HClO_3$.

3. Illustrate the law of multiple proportions with reference to experiments on the composition of the series of lead oxides.

4. Why are the molecules of hydrogen and various other elementary gases and vapours considered to be diatomic?

5. Work out the percentage composition of HNO_3, and find how much quicklime can be obtained from a limestone containing 10 per cent. impurities which themselves lose 20 per cent. of their own weight on ignition.

6. Write an essay on common salt, noticing the following points:—Occurrence, crystallization, purification, freezing mixtures, solubility, boiling-point of solutions, volatility, flame, colouration?

7. How do you prepare pure hydrogen, chlorine, and hydrochloric acid for laboratory purposes?

8. Give a short account of the blast furnace process, and sketch the cup and cone arrangement.

9. Discuss the relative advantages and disadvantages of the different processes of extracting zinc from its ores, and describe either the Belgian or the Silesian process in somewhat greater detail.

10. Define calorific power. Describe some process of charcoal burning. How does the amount of charcoal obtained depend on the temperature of charring and the construction of the apparatus in which the charring takes place? On what depends the specific gravity of the charcoal, its conductivity for heat, and its power of absorbing gases?

CHEMISTRY.

2nd year.

1. What precautions must you take, if you want to find the exact weight of a quantity of some substance by means of a chemical balance?

2. Sketch Westphahl's balance and describe how, by means of it, you can ascertain the specific gravity of a given liquid. How can you find, by the aid of it, the specific gravity of a solid in powder?

3. Explain the following terms by shortly referring to experiments which you have witnessed:—Oxidation, reduction, double decomposition, electrolysis.

4. How is coal gas manufactured?

5. What are exothermal and endothermal reactions? Give examples of both.

6. How would you prepare sulphuretted hydrogen, sulphurous anhydride, carbon bisulphide?

7. Describe the manufacture of cement steel, and state what chemical reactions take place during the conversion of wrought iron into steel.

8. A mineral was found to have the following percentage composition.

SiO_2 ... 39·46, Al_2O_3 ... 21·69, Fe_2O_3 ... 1·36,
CaO ... 35·75, MnO .. 0·96, MgO ... 0·67.

What is its formula?

Physics.

2nd year.

1. How did Regnault determine the absolute density of air?

2. Describe V. Meyer's method of determining the density of vapours.

3. How would you proceed to find the heat of evaporation of a volatile liquid?

Write down the formula which enables you to calculate the latent heat of steam at different temperatures.

4. Starting from the fundamental equations

$$dQ = dU + Pdv,$$
$$\text{and } pv = RT,$$

find the relation between temperatures, pressures, and volumes at the beginning and the end of an adiabatic operation in the case of a perfect gas.

5. What is a cyclical process? Calculate the work done by a perfect gas during a simple Carnot's cycle.

6. State the fundamental laws and principles of geometrical Optics.

7. Describe Faraday's ice-pail experiment. Wherein lies its great importance? How can you modify it (*a*) to show that when two bodies are rubbed together equal quantities of + and — electricity are produced; (*b*) to charge two bodies with quantities of electricity in known proportions?

8. In what ways may magnetic forces be measured?

Estimating.

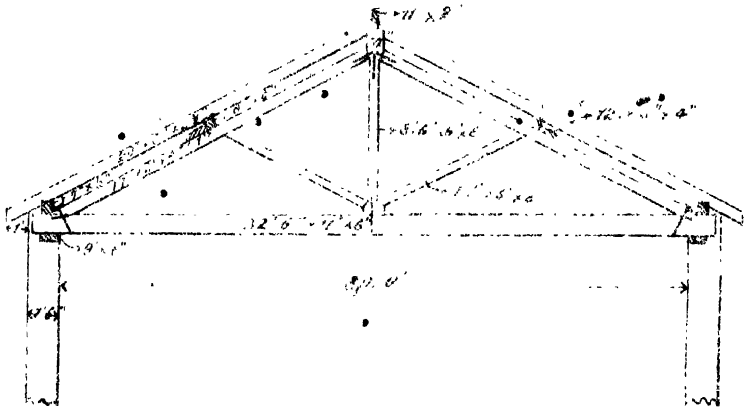
2nd year.

Plate II.

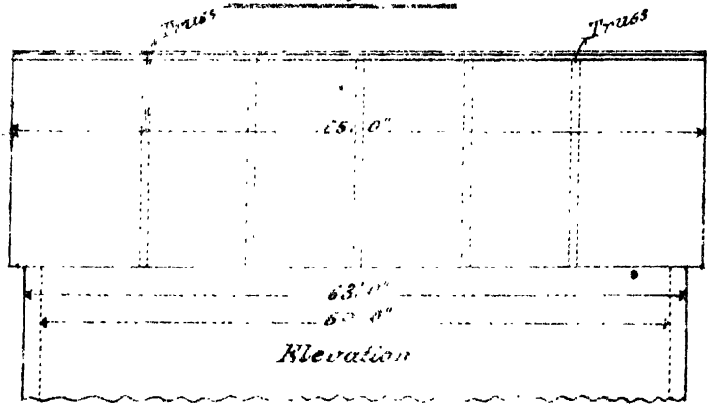
PLATE. II.

King Post Truss.

Scale 8' = 1"



Scale ¼" = 1'



Estimate Woodwork @ 3/- Rs. per cubic foot.
Inner dimension of room 60'×30' Walls 1½ thick
Trusses 10' apart Joints 9" long in Wall Plate 21 a part
Joints in Pur lins 2'-8" long 20 a part
Joints in Pole Plate 2'-4" long 20 a part
C. Rafters 12" a part.
Calculate the area of the roof.

ENGINEER DEPARTMENT.

FIRST EXAMINATION IN ENGINEERING, 1896.

Arithmetic and Algebra.

Examiner—Mr. C. Little, M.A.

1. Simplify

(1) $\left\{ 2\frac{3}{4} + \frac{5}{2} \text{ of } \frac{7}{3\frac{1}{5}} - \frac{1\frac{2}{3}}{2\frac{1}{2}} \right\} \div 1\frac{77}{228}.$

(2) $\cdot 59\dot{3} \div 1{\cdot}78 \times 3\dot{6} \div \cdot 072.$

2. If a sheet of paper $5\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet broad be cut into strips an inch broad; find how many sheets would be required to form a strip that would reach round the earth (25,000 miles).

3. The capital of a mining company is £300,000; the working expenses of the mine amount to £15,691 13*s.* 4*d.* in a given year; what must be the gross proceeds of the mine to pay the original proprietors 4 per cent.? Also, supposing the original shares to be £10, what percentage will those persons receive who have purchased at 2 discount?

4. Reduce $\frac{(a^2-b^2)(x^2-y^2)-4abxy}{(a^2-b^2)(x^2+y^2)+2(a^2+b^2)xy}$ to its lowest terms.

5. Find; if there be one, the greatest common measure of $x^4-3x^3-24x^2+104x-104$ and $2x^4-2x^3+4x^2+2x+6$; also the least common multiple of 12 (a^7b-ab^7) and $(a^2+b^2)^4-(a^4-6a^2b^2+b^4)^2$.

6. Simplify

$$\frac{x^2-x+1}{x^2+x+1}+\frac{2x(x-1)^2}{x^4+x^2+1}+\frac{2x^2(x^2-1)^2}{x^8+x^4+1}.$$

7. Solve the following equations:

(1) $\sqrt{(x+2)(x+3)}+5\sqrt{\frac{x-2}{x-3}}=\sqrt{x^2+6x+8}$

(2) $\left.\begin{aligned} \frac{bx}{y+b}+\frac{ay}{x+a}&=\frac{a+b}{2} \\ \frac{x}{a}+\frac{y}{b}&=2 \end{aligned}\right\}.$

8. Show how to introduce n arithmetical means between two given terms.

Find the sum of $1^3 + 2^3 \ldots\ldots n^3$.

Prove that $\dfrac{a^3 + (a+b)^3 + \ldots (a+nb)^3}{a + (a+b) + \ldots\ldots (a+nb)} = a^2 + nab + \frac{1}{2}n\,(n^2+1)b^2$.

9. Find for what value of r the number of combinations of n things taken r at a time is greatest.

A person has 20 acquaintances, 12 of whom are relatives. In how many ways may he invite 15 guests from among them so that 8 of them are relatives?

10. Expand $(1-4x)^{-\frac{5}{2}}$ to 5 terms and find the general term.

11. Prove that $\log mn = \log m + \log n$

$$\text{and } \log \frac{m}{n} = \log m - \log n.$$

Find the value of $\log_e 10$ correct to the 5^{th} decimal place.

12. Evaluate $6\{\sqrt[6]{65}\}$; and find the logarithm of $(\cdot0045)^{\frac{1}{3}}$ having given that $\log 2 = \cdot301030$ and $\log 3 = \cdot477121$.

Plane Geometry and Geometrical Conics.

Examiner—Mr. C. Little, m.a.

1. Prove that if one side of a triangle be produced, the exterior angle is greater than either of the interior opposite angles.

If ABC be the triangle in the above proposition, and BC be produced to D, prove that the bisectors of the angles ABC and ACD meet on the same side of BD as A.

2. Prove that triangles on equal bases and between the same parallels are equal.

Show how to bisect a triangle by a straight line drawn from a given point in one of its sides.

3. In an obtuse angled triangle prove that the square on the side opposite to the obtuse angle is greater than the sum of the squares on the sides containing it by twice the rectangle contained by either of these sides and the projection on it of the other side.

4. If one angle of a triangle is equal to the sum of the other two, the greatest side is double of the distance of its middle point from the opposite angle. Prove this.

5. Prove that the diameter is the greatest chord in a circle; and that of the others, that which is nearer the centre is greater than one more remote; also conversely that the greater chord is nearer to the centre than the less.

6. The chord AB of a circle is produced both ways equally to C, D, and tangents CE, DF are drawn on opposite sides of CD; show that EF bisects AB.

7. Prove that, in equal circles, angles, whether at the centres or the circumferences, have the same ratio as the arcs on which they stand; so also have the sectors.

8. Prove the following relations for the parabola:

(1) $PN^2 = 4AS.\ AN.$

(2) $QV = 4SP.\ PV.$

9. Draw a parabola to touch a given circle at a given point, and show that its axis may touch the same circle in another given point.

10. If from a point O a pair of tangents OP, OP′ be drawn to an ellipse, prove that OP and OP′ will subtend equal angles at either focus.

11. If PG be a normal to an ellipse and GL be drawn perpendicular to SP, show that the ratio of GL to PN is constant.

12. Prove that the area of any parallelogram formed by drawing tangents to the hyperbola and its conjugate at the extremities P, P′ D, D′ of a pair of conjugate diameters is equal to the rectangle contained by the axis.

Trigonometry and Mensuration.

Examiner—Mr. C. Little, M.A.

1. Describe the various methods which have been adopted for measuring angles.

If an arc of length 10 feet, on a circle of 8 feet diameter subtend at the centre an angle of 143° 14′ 22″; find the value of π to 4 places of decimals.

2. Determine the trigonometrical ratios of the angles 0° and 90°.

Solve the equation

$$\sec\theta \operatorname{cosec}\theta - \tan\theta = 2$$

giving at least two positive and two negative values of θ.

3. If $\sin\theta = \sin a$, prove that $\theta = n\pi + (-1)^n a$.

Prove that the two formulæ

$$(1)\ \left(2n + \tfrac{1}{2}\right)\pi \pm a \text{ and } (2)\ n\pi + (-1)^n\left(\tfrac{\pi}{2} - a\right)$$

denote the same angles, n being any integer. Illustrate by a figure.

4. Prove the following formulæ

(1) $\cos(A-B) = \cos A \cos B + \sin A \sin B$

(2) $2\cos A \sin B = \sin(A+B) - \sin(A-B)$

(3) $\tan 3A = \dfrac{3\tan A - \tan^3 A}{1 - 3\tan^2 A}$.

Show that

$\cos 2a \cos 2\beta + \sin^2(a-\beta) - \sin^2(a+\beta) = \cos(2a+2\beta)$

and $(\tan 4A + \tan 2A)(1 - \tan^2 3A \tan^2 A) = 2\tan 3A \sec^2 A$.

5. Prove that, in a plane triangle,

$$\sin A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}$$

$$a = b\cos C + c\cos B$$

$$\tan\frac{B-C}{2} = \frac{b-c}{b+c}\cot\frac{A}{2}$$

and $a\cos A + b\cos B + c\cos C = 2a\sin B\sin C$.

6. Having given the sides c, a and the angle B of the triangle ABC, find the angles A, C and the side b.

If $b = 131$, $c = 72$ and $A = 40°$, find B and C, having given that

log 5·9 = ·7708520
log 2·03 = ·3074960
L cot 20° = 10·4389341

L tan 38° 36′ = 9·9021604,
diff. for 1″ = ·0002591.

7. Show how to find the height of an inaccessible object.

A round tower stands on an island in a lake. AB are two points on the land such that AB is a feet, and points directly to the middle of the tower. At A and B the base of the tower subtends angles 2α and 2β respectively. Prove that the diameter of the tower is $\frac{2a\sin\alpha\sin\beta}{\sin\beta - \sin\alpha}$

8. A railing is to be constructed of cylindrical posts and two rows of rectangular rails. If the posts be 6 feet long, 6 inches in diameter, and separated by distances of 7 feet; also if the cross section of the rails be a rectangle 6 inches by 1 inch, find the number of cubic feet of timber required for a railing one mile long.

9. In a circle of radius r, a regular polygon of n sides is inscribed, and a circle is inscribed in the polygon. In this circle a second regular polygon is drawn, and in the polygon a circle. If this process be continued ad infinitum, find the sum of the areas of all the circles.

10. Find the slant surface and volume of the frustum of a right pyramid on a regular base of n sides.

The areas of the ends of the frustum being E_1 and E_2 and the thickness k find the volume in the form

$$\frac{k}{3}\left\{E_1 + \sqrt{E_1 E_2} + E_2\right.$$

11. From a cylinder whose height is equal to its diameter, the greatest possible sphere is turned. Find what fraction of the original solid has been cut away.

Statics and Dynamics.

Examiner—Mr. C. Little, M.A.

1. If three forces acting on a particle are in equilibrium, prove that each force is proportional to the sine of the angle between the other two.

The resultant of two forces P, Q, acting at an angle θ is equal to $(2m+1)\sqrt{P^2+Q^2}$: when they act at an angle $\frac{\pi}{2}-\theta$, it is equal to $(2m-1)\sqrt{P^2+Q^2}$: show that $\tan\theta=\frac{m-1}{m+1}$.

2. What is meant by the moment of a force about a point?

Prove that when three forces acting in the same plane are in equilibrium, the sum of the moments about any point in the plane is equal to zero. Consider separately the two cases that arise.

3. AC, BC are two equal uniform rods hinged at C, and have rings at A and B which slide on a smooth parabolic wire whose axis is vertical and vertex upwards: prove that in the position of equilibrium the distance of C from AB is one-fourth of the latus rectum.

4. Find the centre of gravity of a lamina of any shape.

If the centre of gravity of an area be known, and also that of a part of it, show how the C.G., of the remainder may be found.

Apply this method to find the C.G. of a quadrilateral with two sides parallel, expressing the result in terms of the sides of the quadrilateral.

5. Explain the method of dealing with a problem in statics, when one of the conditions is

1) a smooth hinge,
2) a rough hinge.

Two uniform rods of equal weight, but different lengths are hinged together and placed in a vertical plane over two rough pegs in the same horizontal line: if α, β be the inclinations of the rods to the horizon, θ that of the reaction at the hinge which is taken to be smooth, prove that when the rods are on the point of slipping, $2\tan\theta=\cot(\beta+\lambda)-\cot(\alpha+\lambda)$, where λ is the angle of friction.

6. Find the condition of equilibrium of a screw, the power being P and the resistance W.

Find what must be the length of the power arm of a screw having 6 threads to the inch, in order that the mechanical efficiency may be 216.

7. Show that the space passed over in time t by a body, starting with a velocity u and subject to an acceleration f is $ut+\frac{1}{2}ft^2$. Also prove that the velocity v is given by the formula $v^2=u^2+2fs$.

A mass of $1\frac{1}{2}$ tons lies on a smooth horizontal table, and is attached by a light string which passes over the edge of the table to a mass of 28lbs., which hangs freely under its own weight: find how far the masses will move from rest in 2 seconds.

8. What is meant by relative velocity?

A carriage is moving at the rate of 15 miles an hour: a man jumps off giving himself an additional horizontal velocity of 10 miles an hour; find his velocity relative to the ground when he jumps in

a direction making (1) an angle of 60°, (2), an angle of 150° with the direction in which the carriage is going.

9. Find the range and time of flight of a projectile on an inclined plane which passes through the point of projection and makes an angle α with the horizontal.

From a point on an inclined plane (whose inclination to the horizon is 30°) a heavy body is projected perpendicularly to the plane with velocity v. Prove that it will strike the plane again at a point distant $\frac{4v^2}{3g}$ from the point of projection.

10. Calculate the velocities after direct impact of two elastic spheres.

A sphere A impinges on a sphere B of equal mass; their velocities before impact are at right angles and equally inclined to the line of impact, and are equal in magnitude. Shew that when $e=\frac{1}{3}\sqrt{3}$ their velocities after impact are inclined at an angle of 60°.

Analytical Geometry.

Examiner—Mr. C. Little, M.A.

1. What is meant by the cartesian co-ordinates of a point?

Prove that the equation $Ax+By+C=0$ represents a straight line.

Find the equations of the two straight lines which pass through the point (h, k) and are inclined at an angle $\tan^{-1}m$ to the straight line $y=mx+c$.

2. Find the equation of any straight line which passes through the point of intersection of the two straight lines

$$\left.\begin{aligned} a_1x+b_1y+c_1=0 \\ \text{and} \quad a_2x+b_2y+c_2=0 \end{aligned}\right\}$$

Find the co-ordinates of the ortho-centre of the triangle whose angular points are (1, 0), (2, 4) and (−5,−2).

3. $x+y+1=0$, $x-y+2=0$, $4x+2y+3=0$ and $x+2y-4=0$ are the equations to the sides of a quadrilateral taken in order; find the equation to its three diagonals and the equation to the line on which their middle points lie.

4. Trace the circle whose equation is $x^2+y^2+2gx+2fy+c=0$; and find the equation of its tangent at any point $x'y'$.

Find the equation of the circle circumscribing the quadrilateral formed by the straight lines $2x+3y=2$, $3x-2y=4$, $x+2y=3$, and $2x-y=3$.

5. Find the pole of the straight line $ax+by+c=0$ with respect to the circle $x^2+y^2-r^2=0$.

Prove that the polars of the point (2, −1) with respect the circles whose equations are $x^2+y^2+6y+5=0$ and $x^2+y^2+2x+8y+5=0$ coincide.

6. Define a parabola and deduce its equation in cartesian co-ordinates.

A double ordinate of the curve $y^2-4px=0$ is of length $8p$: prove that the lines from the vertex to its two ends are at right angles.

7. Find the equation of the tangent to the parabola in the form $y=mx+\frac{a}{m}$, and prove that the co-ordinates of its point of contact are $\frac{a}{m^2}$ and $\frac{2a}{m}$.

8. If from the vertex of a parabola a pair of chords be drawn at right angles to one another, and with these chords as adjacent sides a rectangle be made, prove that the locus of the further angle of the rectangle is the parabola $y^2=4a(x-8a)$.

9. Prove that the equation of the normal at any point (x', y') on the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}-1=0$ is $\frac{x-x'}{\frac{x'}{a^2}}=\frac{y-y'}{\frac{y'}{b^2}}$.

If $lx+my=n$ is a normal to the above ellipse, show that

$$\frac{a^2}{l^2}+\frac{b^2}{m^2}=\frac{(a^2-b^2)^2}{n^2}.$$

10. Find the equation of the director circle for the hyperbola $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$.

11. Find the equation of a common tangent to the two hyperbolas $x^2-y^2=3a^2$ and $xy=2a^2$; also the co-ordinates of the two points of contact.

GEODESY.

Examiner—RAI KRISHNA CHANDRA BANERJEE BAHADUR.

1. Explain the principle on which verniers are graduated.

The main divisions of the circular arc of a Theodolite show degrees, which are subdivided into 4 parts representing 15 minutes each. The main divisions on the vernier show minutes, and the subdivisions 15 seconds. Make a rough sketch of the scale to read 23° 17′ 45″.

2. Let d be the distance between the tangent points of a serpentine curve, consisting of 2 circular arcs of equal radii r, θ_1, and θ_2, the angles that d makes with the tangents, and a=arc to $\frac{1}{2}(\cos\theta_1+\cos\theta_2)$, then prove that

$$r=\frac{d}{\sin\theta_1+\sin\theta_2+2\sin a}$$

3. Find the distances of the tangent points to the point of contrary flexure of the above curve, and the angles that these distances make with the tangents to the curve.

4. Find the true length of the base line from the following copy of a page from a Field Book.

	Measurements.	Means of measurements.	Angles of inclination.			Means of angles of inclination.			Remarks.
			Degrees.	A.	B.	Degrees.	Min.	Sec.	
1		569·33				—1	29	37	Length of chain before measurement of base = 100·00
2		258·19				0	0	0	Do. after = 100·27
3		396·73				+0	59	13	

5. How do you obtain the correction to be applied on account of the curvature of the earth to the apparent difference of level of two points? Why are no corrections applied for curvature and refraction in ordinary levelling?

6. Check and complete the following portion of a Level Book.

No. of Station.	B. S.	I. S.	F.S.	Distance.	Bearing.	Rise.	Fall.	Reduced level.	Remarks.
1	4·70			5 miles.				77 06	B. M. on mile-stone.
				m. ch.					
				5 1				77·37	
				,, 2				79 92	
				,, 3				79·89	
				,, 4				80·28	
				,, 5				80·38	
				,, 6				80·89	
				,, 7				80·45	
2	11·85			,, 8				80·68	
				,, 9				80·62	
				,, 10				82·01	
				,, 11				86 19	
3				,, 12				89 68	

7. Plot the section to a scale of 200′=1″ horzl., and 20′=1″ vertl. Draw on this Formation line for a road at 5 miles 1 chain, R. L.= 88·00; thence to 5 miles 6 chains there is a falling gradient of 1 in 350; then a rising gradient of 1 in 220 in the remaining portion of the section.

8. In the above section, the slope of the sidelong ground is 1 in 5 from left to right; width at formation 30 feet, slopes 2 to 1. Draw a plan showing thereon the lines of the top width, and the outer edges of side-slopes in cutting and embankment.

9. What do you understand by a circumpolar star? Explain how you would determine the meridian of a place by observation of the maximum elongation of such a star. What is the limit within which the problem is possible?

Materials of Construction.

Examiner—Mr. C. F. Findlay.

1. Describe with sketches any common form of brick-kiln, suitable for temporary use on engineering works.

2. What is the composition, and what are the properties of fireclay?

3. What are the qualities you would look for in a good building stone?

4. Describe the materials necessary for making good mortar, and the precautions to be observed in mixing it. Would you use sea sand? Give reasons for your answer.

5 Describe how the strength of Portland cement is tested. What should be the tensile breaking strength of a sample prepared as you describe?

6 Describe the composition of stucco suitable for covering the outside face of brickwork in Bengal.

7. What is asphalte, and what are its uses?

8. Describe briefly the method by which pig iron is made from iron ore.

9. How is malleable cast iron made, and for what is it used?

10. Describe the method of manufacture of a large cast iron pipe.

11. How is iron wire made? How does its strength compare with that of bar iron of the same composition?

12. In inspecting sawn timber intended for engineering construction, to what points would you give your attention?

Chemistry.

Examiner—Mr. T. H. Holland, A.R.C.S., F.G.S.

1. Describe the preparation of ozone. How does ozone differ in its chemical properties from oxygen? How would you show experimentally that a molecule of ozone consists of three atoms of oxygen?

2. How would you make a qualitative analysis of a mixture containing mercuric nitrate, ferric chloride, carbonate of lime, and ammonic phosphate?

3. Give the properties and illustrate by examples the general modes of obtaining the metallic *carbonates*, *sulphides*, *sulphates*, and *nitrates*.

4. Explain precisely how the determination of the specific heat of a metal affords a means of checking a determination of its atomic weight.

5. Give an account of the manufacture of glass. What is the difference between *flint glass* and *crown glass*? Explain the use of pyrolusite in the manufacture of glass.

6. Describe the preparation and properties of the oxides of nitrogen.

7. In what natural bodies does aluminum occur? Describe the preparation therefrom of (*a*) the pure metal, and (*b*) alum.

8. How could you prove experimentally (*a*) that carbon monoxide contains half its volume of oxygen, and (*b*) that carbon dioxide contains its own volume of that element?

Light and Heat.

Examiner—Mr. J. H. Gilliland, M.A.

1. Show that, when a ray of light is reflected in succession at two plane mirrors which are not parallel, in a plane perpendicular to the line of intersection of the mirrors, the angle between the incident and reflected rays is twice the angle between the mirrors. Describe an optical instrument in which this principle is applied.

2. State the laws of refraction.

Show that the deviation of a ray increases with the angle of incidence. Hence show that when a ray of light passes through a prism, it is bent towards the thicker or the thinner end, according as the index of refraction of the prism is greater than or less than that of the surrounding medium.

3. What is a Simple Harmonic Vibration?

What is the Harmonic Curve?

Given two transverse waves travelling in the same direction with the same velocity, the amplitude and period of one being double the amplitude and period respectively of the other. Give a graphic construction for the resultant wave.

4. Define image, real image, virtual image.

Show how to find the least distance between an object and its real image after refraction through a convex lens.

5. Describe the compound microscope.

Show that the magnifying power of the instrument, considering the lenses as thin lenses, is $\frac{\lambda f}{F(u-f)}$, where λ is the distance of most distinct vision, u is the distance of the object from the object-glass, and F, f are the focal lengths of the object-glass and eye-glass.

6. Give the laws of fusion. Define the latent heat of fusion of ice.

10 lbs. of ice at $-$ 10° C are thrown into 5 lbs. of water at 100°C. Find how much ice will be melted. Sp. heat of ice = ·5. Latent heat of fusion of ice = ·79.

7. Describe Regnault's experiments on the absolute expansion of mercury. Why is it a matter of importance to obtain the absolute expansion?

8. Describe and explain an experiment which illustrates the phenomenon called "regelation."

What is the general law of the effect of increase of pressure on the temperature of fusion?

9. What is meant by the thermal conductivity of a substance? How has it been measured? Give its dimensions in energy units.

10. Describe two only of the following:—

(*a*) Daniell's hygrometer.
(*b*) Otto's Gas Engine.
(*c*) Andrews' experiments on the critical temperature.
(*d*) Dulong and Petit's law of cooling.

Electricity, Magnetism and the Elements of Telegraphy.

Examiner—Mr J. H. Gilliland, M.A.

1. Describe Faraday's "ice-pail" experiments, and the deductions obtained therefrom.

2. Describe the action of some machine for producing, by means of electrostatic induction, electricity at a high potential.

3. Describe the construction of the quadrant electrometer, and give an account of its action.

4. What do you understand by a line of force and a tube of force?

How may the lines of magnetic force near a magnet be determined experimentally?

Sketch the lines of force when the North Poles of two bar-magnets of equal strength are opposed to each other.

5. Explain how it is possible to measure the strength of an electric current.

Distinguish between an astatic and a tangent-galvanometer. Which would you employ to indicate the passage of a small current?

6. How would you measure accurately a large current, say about 1000 Ampères, if you had a galvanometer suitable only for the measurement of small currents, a Clark's standard cell and some resistance-coils?

7. State the fundamental laws of electrolysis.

A current passes through three voltameters in series. One contains a solution of silver nitrate, a second a solution of copper sulphate, and the third acidulated water. After a time it is found that 2·7 grammes of silver are deposited. Calculate the mass of copper, oxygen and hydrogen set free.

$$H=1, O=16, Cu=63, Ag=108.$$

8. What is a transformer? Describe briefly a transformer which will distribute an alternate current of (say) 1000 volts in the high-pressure main to one of 100 volts in a low-pressure main.

What is hysteresis? How does it affect the choice of iron for transformers?

9. Describe the principle of duplex-telegraphy.

Describe how you would proceed to find the position of a fault in a telegraph cable.

10. Describe an accumulator for the storage of electrial energy. Explain its principle, and mention some of the chief precautions to be taken to keep it in good working order.

Drawing.

Examiner.—Mr. W. Banks Gwyther, A.R.I.B.A.

Note.—Neatness and accuracy will be considered in awarding marks; drawings to be in pencil; construction lines to be dotted.

1. On a map a distance known to be 19 miles measures $7\frac{1}{8}''$. Construct a diagonal scale to read miles and furlongs, and long enough to take off 15 miles.

2. Construct an irregular pentagon A. B. C. D. E. from the following data:—Sides, AB = $2\frac{1}{4}''$: BC = $1\frac{7}{8}''$: CD = $2''$: DE = $1\frac{3}{4}''$. Diagonal, AD = $3''$, angles, ABC = 120°; CDE = 112° 50′.

3. A right hexagonal prism, of $1\frac{1}{2}''$ sides and $2\frac{1}{2}''$ height, stands on end with one of its sides parallel to, and $1''$ distant from the vertical plane. Find the shadow cast by it on both planes from a luminous point placed $4''$ above the horizontal and $5''$ from the vertical plane, and 6′ distant from the axis of the prism.

4. Draw the elevation of a timber truss to carry a tiled roof from the following specification:—

Clear span	24′ 0″
Thickness of walls ...	1′ 8″
Slope of roof	27°
Principal rafters	6″ × 4¾″
Tie beams	6″ × 4¾″
King-post (least section) ...	6″ × 4″
Ridge pole ...	× 2″
Purlins	6″ × 6″
Pole plates	5″ × 4″
Common rafters	4¾″ × 2½″
Batten to carry tiles (10″ apart in the clear).	1½″ × 1½″

All straps, bolts and cleats to be shown, but not the roofing tiles.

Truss to rest upon stone plates 3″ thick placed on the walls.

Scale ⅜″ = a foot.

5. Make a freehand perspective sketch in light and shade of the group of objects illustrated in Plate I, Fig. 2, the position of the spectator being 15′ off and the height of his eye about 5′ above the ground.

ENGINEER DEPARTMENT.

L.E. AND B.E. EXAMINATIONS, 1896.

Differential and Integral Calculus.

Examiner—Mr. C. Little, M.A.

1. Define a differential co-efficient, and from the definition deduce its value for the following functions, (1) $f(x) \times \phi(x)$, (2) x^n, (3) $\tan^{-1} x$

Differentiate

$$(1)\ \log \frac{\sqrt{b+a}+\sqrt{b-a}\,\tan\frac{x}{2}}{\sqrt{b+a}-\sqrt{b-a}\,\tan\frac{x}{2}}$$

$$(2)\ (1+x^2)^{\frac{m}{2}} \sin(m \tan^{-1} x)$$

$$(3)\ \left(1+\frac{1}{x}\right)^x + x^{1+\frac{1}{x}}.$$

2. If $\sin x + \sin 2x + \ldots\ldots + \sin nx$

$$= \frac{\sin\frac{n+1}{2}\,x \sin\frac{nx}{2}}{\sin\frac{x}{2}}$$

deduce by using the process of differentiation the sum of $\cos x + 2\cos 2x + \ldots\ldots + n \cos nx$.

3. If $y = \log x$, prove that

$$\frac{d^n y}{dx^n} = \frac{\lfloor n-1\ (-1)^{n-1}}{x^n}$$

Also if $n = e^{ax} \cos bx$, prove that

$$\frac{d^2 n}{dx^2} = r^2 e^{ax} \cos(bx + 2\phi)$$

where $a = r \cos\phi$ and $b = r \sin\phi$.

4. If $y=e^{-x}\cos x$, prove that

$$\frac{d^4y}{dx^4}+4y=0.$$

If $y=e^{ax}\sin bx$, prove that

$$\frac{d^ny}{dx^n}-2a\frac{d^{n-1}y}{dx^{n-1}}+(a^2+b^2)\frac{d^{n-2}y}{dx^{n-2}}=0$$

5. Expand $e^x\log(1+x)$ in ascending powers of x, showing that the co-efficient of x^5 is $\frac{9}{5}$.

6. Prove that $\tan^{-1}x=x-\frac{x^3}{3}+\frac{x^5}{5}-\ldots\ldots$

7. Explain how maximum and minimum values of a function are found and discriminated.

Find the maximum and minimum values of the following functions:—

(1) $x^3-9x^2+24x-7$,

(2) $\frac{a}{\sin^2x}\cdot\frac{b^2}{\cos^2x}$

8. Integrate the following standard forms

$$\frac{x^n}{a+bx^n},\ \frac{dx}{\sqrt{a^2-x^2}},\ \frac{dx}{x^2-a^2},\ \frac{dx}{a+2bx+cx^2}\text{ and }\frac{d\theta}{a+b\cos\theta}.$$

9. Evaluate the following expressions—

$$\int\frac{dx}{x^2+9x+20},\ \int\frac{xdx}{(a+bx)^{\frac{1}{2}}},\ \int\frac{dx}{(a+2bx+cx^2)^{\frac{1}{2}}}\text{ and }\int\sin^3\theta\,d\theta.$$

10. Prove the following formula of reduction—

$$\int\sin^m\theta\,d\theta=-\frac{1}{m}\cos\theta\sin^{m-1}\theta+\frac{m-1}{m}\int\sin^{m-2}\theta\,d\theta$$

and find the value of $\int\sin^6\theta d\theta$.

11. Find the area of a closed curve whose equation is given in polar co-ordinates.

Find the area of a loop of the curve $r=a\cos 3\theta$.

12. Find the volume included by the surface obtained by revolving the parabola $y^2=4ax$ about the axis, and a plane at right angles to the axis at a given distance from the vertex.

Hydrostatics.

Examiner.—Mr. C. Little, M.A.

1. How is pressure at a point in a fluid measured?

Describe an experiment which proves that the pressure of fluid increases with the depth, and that it is sufficient, below a certain depth to support a given weight.

2. Prove the equality of pressure at any point of a fluid in all directions.

3. A cylindrical pipe which is filled with water opens into another pipe, the diameter of which is three times its own diameter. If a force of 20 lbs. be applied to the water in the smaller pipe, find the force on the open end of the larger pipe, which is necessary to keep the water at rest.

4. Define specific gravity, and describe any method of comparing the specific gravities of two liquids.

A piece of copper and a piece of silver fastened to the two ends of a string passing over a pulley hang in equilibrium when both are entirely immersed in a liquid whose specific gravity is 1·15. Find the ratio of the volumes of the copper and silver, the specific gravities of silver and copper being 10·47 and 8·89.

5. Find the pressure at any depth in a heavy homogeneous liquid at rest; and prove that the pressures at any two points in the same horizontal plane are the same, when the line joining the points does not lie entirely within the liquid.

A fine tube A B C is bent, so that the portions A B, B C are straight and perpendicular to one another. The tube is placed so that each branch is equally inclined to the vertical and equal quantities of two liquids, the densities of which are in ratio of 2 : 1, are poured into the respective branches. Find the height above B of their common surface.

6. Find the whole pressure and the horizontal pressure on a given surface exposed to fluid pressure.

A solid hemisphere, completely immersed in liquid of density ρ, is held so that the centre of its base is at a depth C below the surface, and the plane of its base inclined at an angle θ to the vertical, find the horizontal and vertical pressures on the curved surface and prove that if P be the resultant pressure $P^2 = g^2\rho^2\pi^2a^4\left(c^2 \pm \frac{4}{3}ac\sin\theta + \frac{4}{9}a^2\right)$, where a is the radius.

7. Find the conditions of equilibrium of a body partially immersed in liquid.

Prove that the equilibrium is stable, unstable or neutral according to the relative positions of the centre of gravity of the body and a point called the metacentre.

8. Describe Torricelli's experiment.

A closed air-tight cylinder of height $2a$ is half full of water and half of air at atmospheric pressure. Water is introduced without letting air escape so as to fill an additional length k of the cylinder, and the pressure at the base is doubled, Prove that

$$k = a + h - \sqrt{h^2 + ha}$$

where h is the height of the water barometer.

9. Explain the action of the Siphon.

10. Describe Hawksbee's air-pump, and find the pressure of air in the receiver after n strokes.

In the process of exhausting a common receiver, after 10 strokes of the pump the mercury in the gauge stands at 20 inches, the barometric height being 30 inches. At what height will the mercury in the gauge stand after 20 more strokes?

11. Compare by means of the hydrostatic balance the specific gravities of a solid and a liquid, taking into consideration the air displaced by the solid.

GEOLOGY.

Examiner.—MR. T. H. HOLLAND, F.G.S., A.R.C.S.

1. From what evidences have the temperature and density of the Earth's interior been determined?

2. Give an account of the microscopic characters of the following rocks: *hornblende-andesite*, *prophyritic hornblende-granite*, *sanidine-trachyte*, *gabbro*, and *quartz-porphyry*.

3. Describe the ways in which atmospheric agents contribute,

(*a*) to the formation of soils,
(*b*) to the formation of landslips.

4. Illustrate the different varieties of faults and explain the nature of a thrust-plane.

5. With the examples from the European Tertiary rocks show how fossils indicate—

(*a*) changes in climate,
(*b*) changes in topography.

6. Classify the following fossils zoologically and give the geological age of each,

Lima gigantea, Astarte borealis, Paradoxides Davidis, Galerites albo-galerus, Lingulella Davisii, Ammonites planorbis, Monograptus priodon, Avicula contorta, Pentamerus Knightii, Ceratites nodosus, Cephalaspis Lyelli, Encrinus liliiformis, Lithostrotion basaltiforme, Productus horridus, Pleurotomaria carinata.

7. Give a geological description of the Giridih coalfield.

8. Point out precisely how the different geological histories of peninsular and extra-peninsular India are expressed in their present physical features.

9. To what is the usual shape of a volcano due? Indicate the chief facts concerning the geographical distribution of volcanoes.

10. How is the true dip of a bed calculated from two apparent dips taken in different azimuths?

Mineralogy and Metallurgy.

Examiner—Mr. T. H. Holland, F.G.S., A.R.C.S.

1. By tracing the relations between the seven holohedral forms of the cubic (regular) system, indicate precisely what is meant by the term "limiting forms."

2. When the crystalline form is wanting, show how would you distinguish by their optical characters alone,—

(*a*) horizontal from vertical sections of quartz.
(*b*) clinopinacoidal from orthopinacoidal sections of augite.
(*c*) horizontal sections of quartz from horizontal sections of calcite.
(*d*) a sheet of muscovite from a sheet of biotite.
(*e*) a red spinel from a ruby.

3. What is Sonstadt's solution? State precisely how you would by the use of this solution distinguish—

(*a*) small fragments of quartz from those of diamond.
(*b*) small fragments of anorthite from those of orthoclase.
(*c*) quartz from colourless topaz.
(*d*) graphite from black mica.

4. Describe the minerals forming the group of isomorphous metallic sesquioxides (R_2O_3).

5. Give the names, chemical compositions, and crystalline forms of the minerals represented by specimens exhibiting the following properties:—

(*a*) Black, non-magnetic octahedra giving a brown streak. Hardness 5·5. Becomes magnetic after heating before the blowpipe. Gives a green bead with borax and microcosmic salt.

(*b*) Brass-yellow cubes which burn in the oxidizing flame of the blowpipe with evolution of sulphurous anhydride, leaving a magnetic residue.

(*c*) Pale green, hexagonal crystals soluble in nitric acid. Solution gives a yellow precipitate when treated with ammonic-molybdate, and a white precipitate when treated with ammonia in excess and ammonic oxalate. Hardness of crystals, 5. Sp. Gr. 3·2.

(*d*) White rhombohedra. Hardness 4. Sp. Gr., 3·1. Infusible before the blowpipe, giving a pink residue on ignition after treatment with nitrate of cobalt. Soluble with effervescence in hot hydrochloric acid; the solution gives no precipitate with ammonia and ammonic oxalate, but gives a white precipitate on addition of sodic phosphate.

(*e*) Deep blue crystals. Turned black and give off water on heating in a closed tube. Dissolved with effervescence in nitric acid forming a green solution, which turned blue on addition of ammonia.

6. Give an account of the properties of *cement copper*. How are its properties affected by the introduction of small quantities of iron, sulphur, antimony, arsenic, bismuth and lead? What is the usual cause of the brittleness of *dry copper*, and how is it removed?

7. Describe exactly how you would make a proximate assay of a sample of coal, and determine its calorific power.

8. Describe the process of making the so-called Siemens-Martin steel, and the chemical reactions involved.

9. Describe Plattner's process for the treatment of auriferous arsenical pyrites.

10. Classify the dry processes employed for the extraction of metals from their ores.

Details of Construction.

Examiner—Rai Krishna Chandra Banerjee, Bahadur, B.A.

1. What are the considerations that should guide you in determining the best form of roof truss for a given span?

2. What is the rule often adopted for the proportion of tread and riser in steps of the dimensions ordinarily required in practice?

3. Give a specification for pointing plaster.

4. The arch spanning a stream has a span of 30 feet, rise 3′-6″, and thickness at crown 2′-6″. Draw a section of the arch to a convenient scale, showing the bond you would use, giving reasons.

5. Sketch and describe the pneumatic method of tunnelling now being used in the construction of the Thames Tunnel.

For what class of soil is this method most suitable?

6. Give a sketch of an iron truss of 50 feet span, with a continuous ridge ventilator, showing clearly the enlarged details of all the joints.

7. Show by sketch the form of Barton's rivetted joints for cover plates, giving dimensions proposed by him.

8. (*a*) Note the cases in which drilled and punched holes may respectively be used.

(*b*) What are the causes of failure in rivetted joints?

9. Give a specification for a first class brick bridge with deep well foundations over a sandy river.

10. A light-house is built of brick masonry 120 feet high above the sea level. The internal diameter is 12 feet, and the thickness of walls at top 4 feet 2 inches. It is proposed to lay 3 courses of stones, each 1 foot in height, on top, to provide a solid bed for the iron superstructure of the lantern to be erected thereon,—

(*a*) Explain by a sketch how you intend lifting these stones on top, considering each stone to be not less than a ton in weight.

(*b*) Give plan and section of the form of joints you would use, and note the precautions you would take to secure the 3 courses of stones firmly together, so that they may not be blown away by the force of a cyclone.

Roads and Railways.

Examiner—Rai Krishna Chandra Banerjee, Bahadur, B.A.

1. In aligning a road over a hill, one of the sides of which is wooded and the other comparatively bare, which side would you generally choose for the alignment of your road?

2. Name some of the instruments used in tracing a line on a hill.

3. How would you take a road along the face of a nearly perpendicular precipice at a considerable height?

4. Sketch neatly the following cross-sections, giving all necessary dimensions—

(*a*) Half cross-section of a first class road on level ground in land of ordinary value.

(*b*) Full cross-section of a road on side of a steep hill, showing retaining and breast walls clearly, and sketching the arrangements for draining the road efficiently.

(*c*) Half cross-section of embankment for broad gauge line on level ground, showing all details on one side completely.

(*d*) Full cross-section of a tramway, showing details of foundations, and sections of rails that you consider best to use.

5. What functions are discharged by the "metal" of a road, and the "ballast" on a railway.

6. Detail the conditions that should be complied with, to ensure that the permanent way may be strong enough to bear without damage the heaviest loads which can come upon it.

7. Describe the Rigi ladder Railway, and compare it with Fell's Railway. What are the special advantages claimed for each, and the gradients each has actually worked over?

8. If the total weight of a train = 200 tons;
Weight of carriages braked = 50 ,,
Speed of train = 30 miles per hour,
Inclination of the gradient = 1 in 150,
Coefficient of rolling friction = 10lbs. per ton.
Ditto of sliding friction = 20 p. c. of weight of carriages braked,

find the distance the train will run after the brakes are applied.

9. (*a*) To what extent and why is a train's motion affected when traversing a curve, and how may this be counteracted?

(*b*) What is the minimum radius permissible on a railway curve?

(*c*) Describe a contrivance by which rolling stock of ordinary length may be adapted for sharp curves.

10. What will be the resistance of the train in Question 8?—

(*a*) on a level,

(*b*) when the gradient is 1 in 132.

11. Explain the "block" system of signalling. What are its advantages over "time signalling"?

Hydraulic Engineering.

Examiner—Mr. C. F. Findlay, M.A., M.I.C.E.

N.B.—Whenever sketches are required, they should be fully dimensioned.

Full marks for the paper may be obtained without answering all the questions.

1. It is desired to utilize the power of a stream of water having an available minimum flow of 80 cubic feet per second with a fall of 15 feet. Calculate the effective H. P. that might be obtained on the shaft of a turbine whose efficiency is 60 per cent.

2. Describe any form of turbine suitable for the case mentioned in question 1, and sketch the form of the blades. Give approximate dimensions and speed.

3. Define the term "hydraulic mean depth."

Establish the formula giving the discharge of an open channel in terms of its inclination section, and hydraulic mean depth.

A certain river, having, over a fairly uniform part of its course, a slope of 3 inches per mile, is found to have a section of 6,200 square feet, a wetted perimeter of 1,550 feet, and a mean velocity of 1½ feet per second. Find from these data the coefficient of discharge in your formula, for the river in question.

4. A canal lock, 40 feet wide, is closed by a pair of gates having a rise of 8 feet (from meeting point of gates to line joining centres of heel posts). Find the amount and line of application of the resultant pressure of each gate on the lock wall, when the water stands 18 feet deep on one side of the gate and 6 feet deep on the other side.

5. The rain-water from a shed roof, 1,500 feet long by 60 feet wide, is stored in a tank, one acre in extent, with vertical sides. What depth must the tank be, if the rainfall is 40 inches per annum distributed over 3 months, and the consumption uniform throughout the year?

Allowing for 10 inches of evaporation per annum from the tank and 5 per cent. of loss from other causes, what daily supply in gallons could be obtained from the tank?

6. In designing a masonry dam to retain water, on what principles should the thickness at various heights be determined?

Explain why a right angled triangle is preferable to an acute angled triangle as the form of the section for a triangular dam, and on which face the water pressure should be.

7. Enumerate the considerations which would determine whether an earthen dam or a masonry dam should be chosen for a particular site.

8. Describe the phenomenon in rivers known as "scour."

In constructing works in rivers liable to scour, describe briefly methods of protection that may be adopted explaining wherein the protective value consists.

9. Describe with sketches an appropriate method of construction for a weir across a wide shallow river in a bed of heavy quartz sand, subject to floods of short duration, the object being to retain all the flow during the dry season and to allow the floods to pass as freely as possible.

10. In designing underground sewers, on what principles are the cross-sections to be chosen?

A brick sewer is to be designed for a minimum flow of 10 cubic feet per second and a maximum flow of 30 cubic feet. A minimum velocity of 3 feet per second is considered necessary to prevent deposit. Sketch an appropriate cross-section.

11. Explain the advantage of the "accumulator" in hydraulic machinery.

A pumping station with an accumulator is required to work cranes at a distance of 2 miles from the station. Why is it advisable in such a case to have a second accumulator near the cranes?

12. An impounding reservoir is 7 miles distant from the service reservoir and 50 feet above it. The main is 18 inches in diameter and nowhere rises above the hydraulic grade line. Find the daily delivery in gallons by the formula $V = c\sqrt{rs}$, where $c = 125$.

Applied Mechanics.

Examiner—Mr. C. F. Findlay, M.A., M.I.C.E.

N.B.—Whenever sketches are required they should be fully dimensioned.

Full marks for the paper can be obtained without answering all the questions.

1. Define the terms bending moment and moment of resistance as applied to a beam. If $(x, y,)$ be any point on the axis of a beam referred in the usual way to rectangular co-ordinates, and the load on the beam per unit of length at that point be w, M being the bending moment, prove that

$$\frac{d^2M}{dx^2} = -w.$$

A beam resting freely on bearings 20 feet apart carries a load of 1 ton per foot. Find at what points of its length there is a bending moment of 42 foot-tons.

2. A jib-crane lifts 10 tons at a radius of 12 feet from the axis of its post, the chain hanging in 5 falls. The length of the jib is 20 feet and that of the post 22 feet. Find the stresses in the jib and the tie (*a*) when the chain passes along the jib, and (*b*) when it passes along the tie.

3. State the grounds on which greater strength is provided in a bridge to carry rolling loads than to carry the same loads at rest.

4. A train weighing 600 tons moves at a speed of 15 miles per hour up a gradient of 1 in 150, the resistances, apart from gravity, amounting to 12 lbs. per ton. Find the effective H.P. exerted by the engine.

What must be the weight on the driving wheels that they may not slip with a coefficient adhesion of $\frac{1}{7}$th ?

5. Investigate the relation between the tensions in the two parts of a driving belt.

6. A suspension bridge carries a uniformly distributed load of 15 cwts. per foot lineal. The span is 100 feet and the dip of the ropes 10 feet. Find the tension in the ropes at the lowest and highest points and the load on the piers.

7. AB and AC are two members of a bridge having a stress of 8 tons in each and united at A by a pin. AB is a flat bar 1 inch thick, and AC consists of two bars each $\frac{1}{2}$ inch thick.

What should be the diameter of the pin that the tensile stress in it should nowhere exceed 5 tons per square inch, nor the shearing stress exceed 4 tons per sq. in ?

8. A locomotive has 4 driving wheels of 5 feet 6 inches diameter and at 8 feet apart, centre to centre, with cylinders of 21 inches stroke. If the coupling rods weigh 15 lbs. per foot lineal, each, find the bending moment produced in them by the speed of rotation, when the engine is travelling at 50 miles per hour.

9. A wrought iron water tank is built in the form of an inverted cone supported at the circular upper edge. Find the maximum circumferential stress and the stress along any generating line of the cone in terms of the depth and the angle.

10. A girder of 100 feet span is 10 feet deep and divided into 10 bays with vertical struts and diagonal ties. Draw the "influence lines" of stress in the end diagonal and in the middle of the boom,—*i.e.*, diagrams respectively representing the stresses required, for all positions on the girder of a single isolated load of 1 ton.

MECHANISM AND STEAM ENGINE.

Examiner—RAI KRISHNA CHANDRA BANERJEE, BAHADUR, B.A.

N.B.—Candidates are supposed to use a table of Logarithims for this paper.

1. The centres of two shafts are 9′-6″ apart, on these shafts pulleys of 30 and 12 inches diameter are respectively keyed. Find the

length of crossed belt required to connect the two pulleys. If the 30-inch pulley formed the largest step, and 12-inch pulley the smallest step of two coned pulleys respectively, and if the former be on a shaft which rotates at the constant speed of 200 revolutions per minute, find the diameter of the remaining two steps of each cone, the required speeds of the driven shaft being 250, 300 and 400 revolutions per minute.

2. The pitch of a screw-jack is $\frac{5}{8}$ inch, and the distance from the axis of the screw to the end of the handle 28 inches. Find the velocity ratio, and the load which will be lifted by a force of 112 lbs. applied at the end of the handle.

3. (*a*) Define the terms:—angle of advance of eccentric, lap, lead, travel of a slide valve, and clearance of a piston.

(*b*) The travel of a slide valve is 5 inches, the outside lap $\frac{3}{4}$ inch, the inside lap $\frac{3}{8}$ inch, the angle of advance 32°. Construct a Zeuner's diagram, showing the positions of the crank, when the admission takes place, the steam is cut off and released, the exhaust closed, and the amount of the lead.

4. If the law of the expansion curve of an indicator diagram be pv^n = constant:—

(*a*) Find the law of the expansion curve of a diagram, the following being the values of p and v, represented by the ordinates of points on the curve:—

Number of ordinate.	p. in lbs. per square inch (absolute).	v. in cubic feet.
1	41·49	6·99
2	40·96	8·11
3	37·58	10·01
4	33·78	10·89

(*b*) Give the actual amounts of evaporation taking place at different parts of the stroke.

5. Explain by sketches why the cut-off occurs earlier with an eccentric having a short throw than with one which gives more travel to the valve.

How do eccentrics with a short throw, and valves with a corresponding amount of lap, affect the admission with a link-motion, as compared with eccentrics having a larger amount of throw, and greater lap of valve?

6. (*a*) What will an indicator diagram show? What are the principal causes that affect its form?

(*b*) An indicator diagram is divided horizontally into 8 equal parts by ordinates drawn at right angles to the atmospheric line, the lengths in inches of these ordinates being as follow:- 0, 1·64, 1·23, 0·9, ·74, ·6, ·49, ·35, 0. The greatest length of the diagram parallel to the atmospheric line is 4 inches. Scale of pressure, 35 lbs. per square inch= one inch. The following are the dimensions of the engine from which the diagram is taken. Diameter of piston=12″, length of crank=12″.

Speed 100 revolutions per minute.

Find the indicated H. P. of the engine.

7. Find the bursting pressure of a spherical boiler 7 feet in diameter, the thickness of the metal being $\frac{2}{8}$ inch, the joints being neglected.

Breaking stress in tension=47,040 lbs per square inch. If the rivetted joints diminish the strength of the boiler 30 per cent., find the bursting pressure.

8. Find the power necessary to draw a train weighing 200 tons up an incline 1 in 300, at the steady rate of 25 miles an hour, the resistance to motion on a level road at the rate being 15 lbs. per ton.

9. (*a*) On what conditions does the correct working of the teeth of wheels and racks depend?

(*b*) What is the best value on the whole for the *mean obliquity* of action in tooth gearing, found in ordinary practice.

(*c*) *A* is a centre pin carrying a fixed spur wheel. About the axis of that wheel there turns a disc, carrying a set of diverging epicyclic trains. Each epicyclic train consists of a spur wheel *B*, gearing with the fixed wheel *A*, and another spur wheel *C* gearing with *B*. The last spur wheel *C* is exactly equal in radius and in number of teeth to the fixed wheel *A*. Find the angular velocity of the wheel *C*, when the disc rotates. *See* Fig. 3, Plate I.

Drawing.

Examiner—Mr. W. Banks Gwyther, A.R.I.B.A.

Note.—Drawings should be done in pencil only, working lines being drawn lightly or dotted and results distinguished by firm lines. Neatness and accuracy will be considered in awarding marks.

1. Make drawings to a scale of 1″=1′ of the following. See Fig. 1, Plate III.

2. A thin plate poised in the position indicated below is set in motion through space in the following manner:—

It first moves vertically to the extent of 2,″ and is then tilted on its right edge through an angle of 45°. After travelling horizontally to the left for a distance of 3″ it moves upwards to the right in a direction making an angle of 60° with the horizon.

Supposing the space thus cut through to form a solid, draw its form and the shadow cast by it on the vertical and horizontal planes by light falling at the conventional angle. See Fig. 2, Plate III.

3. Design plan and section of a building for a small out-door dispensary to be erected on a rectangular corner site measuring 90′ × 60′; the following are the requirements :—

Accommodation.—Waiting hall for patients about 500 superficial feet.

Doctor's room about 250 superficial feet.

Examination and operating-room about 200 superficial feet.

Doctor's retiring-room about 50 superficial feet.

Medicine waiting-room and dispensary together about 300 superficial feet.

The accommodation to be so arranged and divided as to permit of males and females being separated from moment of entering to their leaving the dispensary: the proportion of male to female patients being as 2 to 1.

Construction.—Pucka brickwork throughout; flat terraced roofing; Mirzapore stone flooring; height of plinth 2 feet; height of rooms 15 feet; principal doors 4′ × 8′.

4. Draw freehand and in rough perspective a sketch of the architectural feature in Fig. 3, Plate III, imagining yourself to be in the position indicated at A and your eye to be at the ordinary height above ground.

OPTIONAL SUBJECTS.

Pure Mathematics.

Examiner—Mr. C. Little, M.A.

1. Simplify $\dfrac{3\sqrt{8}-2\sqrt{12}+\sqrt{20}}{3\sqrt{18}-2\sqrt{27}+\sqrt{45}}$.

2. Solve the following equations

(1) $\sqrt{2x+5a}-\sqrt{2x}=\dfrac{}{\sqrt{5a-2x}}$

(2) $x^2+xy+y^2=13$

$x^4+y^4=82.$

3. If $(1+x)^n=c_0+c_1x+c_2x^2+\&c\ldots+c_nx^n$ prove the following identity

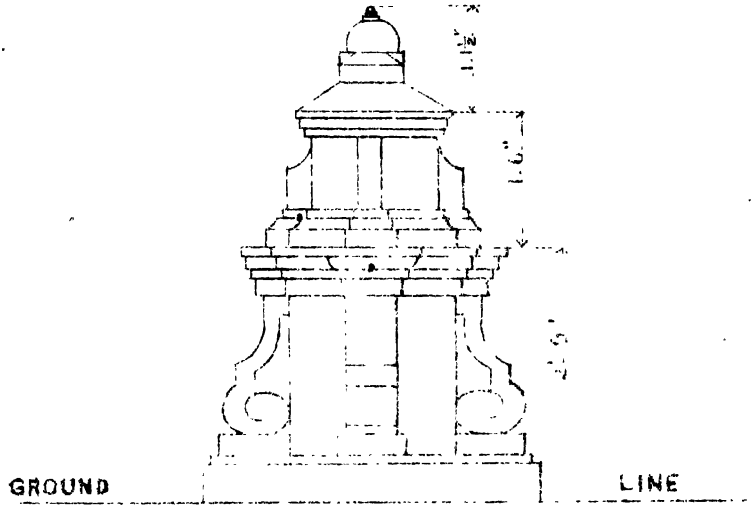
$$1+3c_1+7c_2+\ldots(n^2+n+1)c_n=2^{n-2}(n^2+3n+4).$$

4. Prove the following identities

(1) $(\cos A+\sin A)(\cos 2A+\sin 2A)(\cos A-\sin 3A)$
$=\cos 2A\cos 4A.$

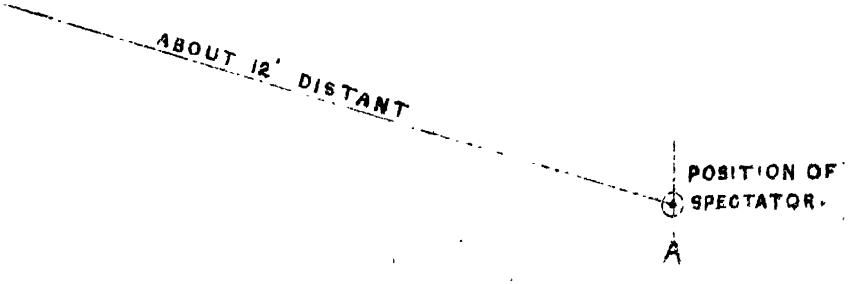
(2) $\sin 85°=\cos 55°+\sin 25°.$

PLATE III.



ELEVATION

FIG. 3.



5. Two lines of straight railway, ABC, DEC meet at C, telegraph posts being situated at A, B, D, E: the angles DAE, DBE are each equal to a; and the angles EAB, EBC are β and γ respectively show that

$$BC = AB \frac{\sin\beta \sin(a+\beta)}{\sin(\gamma-\beta)\sin(a+\beta+\gamma)}.$$

6. If R be the radius of the circle circumscribing the triangle, ABC, and p, p', p'' the perpendiculars from the centre on the sides of the triangle, prove that

$$\frac{a}{p} + \frac{b}{p'} + \frac{c}{p''} \quad \frac{1}{4}\frac{abc}{pp'p''}.$$

and $a\cos A + b\cos B + c\cos C = 4R\sin A\sin B\sin C$.

7. Find the equation of the parabola when the vertex is origin and the axis of the curve and tangent axes of co-ordinates.

Prove that the equation of the chord of the parabola whose middle point is $(x_1\, y_1)$ is

$$y - y_1 = \frac{2a}{y_1}(x - x_1).$$

8. Two points P and P′ on an asymptote of an hyperbola subtend a right angle at the focus S, prove that

$$\frac{1}{SP^2} + \frac{1}{SP'^2} = \frac{1}{b^2}.$$

Mixed Mathematics.

Examiner—Mr. C. Little, M.A.

1. Four forces P, Q, R and S no two of which are parallel, act in a plane: the resultant of P and Q meets that of R and S in A, the resultant of P and R meets that of Q and S in B, and the resultant of P and S meets that of Q and R in C: prove that A, B and C are in the same straight line.

2. Two uniform rods AB, BC, of lengths $2a$, $2b$ respectively, are rigidly united at B and are suspended freely from A. If they rest inclined at angles θ, ϕ respectively to the vertical, show that

$$\frac{\sin\theta}{\sin\phi} = \frac{b^2}{a^2 + 2ab}$$

3. A lamina in the form of an isosceles triangle, whose vertical angle is a, is poised upon a sphere, radius r, so that its plane is vertical, and one of its equal sides (a) is upon the surface of the sphere, show that the equilibrium will be stable in the plane of the triangle if $\sin a$ be less than $\frac{3r}{a}$.

4. A rough hemisphere rests with its convex surface against a vertical and a horizontal plane. If θ be the inclination of the base to the vertical in the limiting position of equilibrium, show that

$$\sin\theta = \frac{8\mu(1+\mu)}{3(1+\mu^2)}$$

the planes being equally rough.

5. If A B is the horizontal diameter of a circle, C the lowest point of the vertical diameter, find a point P on the circle such that if t, t', t'' are the times of falling from rest down PC, PA, PB respectively, then

$$t' - t'' = t\sqrt{2}.$$

6 A particle is projected at an angle a with a velocity v and strikes at right angles a plane passing through the point of projection, and inclined at an angle β to the horizon. Find the time of flight and the range on the plane Show also that the condition

$$\tan a = \frac{1+\sin^2\beta}{\sin\beta\cos\beta} \text{ must hold.}$$

7. A heavy elastic ball drops from the ceiling of a room, and after twice re-bounding from the floor just reaches a point half the height of the room. Show that its elasticity is $\frac{1}{4}\sqrt{5}$.

CHEMISTRY.

Examiner—MR. T. H. HOLLAND, F.G.S., A.R.C.S.

Wherever possible chemical changes should be expressed by equations.

1. What is meant by *chemical affinity*? Give illustrations showing the influence of variations in temperature and pressure upon the progress and direction of a chemical change.

2. Describe the manufacture from any one of its natural sources, and give an account of the allotropic modifications, of phosphorus.

3. Calculate the atomic weights of silver and lead from the following data:—100 grammes of silver gave 132·84 grammes of silver chloride. 9·9950 grammes of lead chloride required 7·762 grammes of metallic silver for complete precipitation. Atomic weight of chlorine, 35·37.

4. Upon what experimental evidence is Avogadro's law based?

5. Describe exactly how you would make a standard solution of potassic bichromate for volumetric analysis, and explain with equations its use in the estimation of iron in an iron-ore.

6. Compare the properties of the various members of the group of halogens, and describe the methods employed for extraction of these elements from their sources in Nature.

7. How would you determine the vapour density of a substance? How do you explain the decrease which takes place in the vapour densities of some bodies as the result of a rise in temperature?

8. Give an account of the preparation and properties of cyanogen and hydrocyanic acid.

9. What is meant by *the law of isomorphism*? How has this law been employed in the determination of atomic weight?

10. Describe the method employed by Bunsen and Roscoe for the quantitative determination of the chemical action of light. What photo-chemical laws have been established by this means?

PHYSICS.

Examiner—MR. T. H. HOLLAND, F.G.S., A.R.C.S.

1. Describe a method of finding the velocity of light.

2. Obtain the formula $\frac{1}{x}+\frac{1}{x'}=\frac{2}{r}$ for reflexion at a spherical mirror, where x, x', r are measured from the mirror.

You are standing in front of a spherical mirror which you cannot get at. How can you tell whether the mirror is convex or concave?

3. Describe the principle parts of a spectroscope, giving the uses of each.

4. Describe Galilei's telescope.

How is the achromatism of the objective secured? Give the calculations.

5. Describe Regnault's method of finding the maximum pressures of vapours at ordinary temperatures.

6. What is the relation between the coefficient of linear and cubical expansion of a metal?

An iron bottle contains 20 lbs. of mercury at 0°C, but at 100°C it only contains 19·72 lbs. The coefficient of linear expansion for iron is ·000012. Find the coefficient of cubical expansion of mercury.

7. Describe briefly the experiments by which Dr. Joule determined the value of the mechanical equivalent of heat.

8. Describe Ramsden's electrical machine.

9. Give a general description of the method of distributing power for illumination with incandescent lamps by a system of alternating currents, the E. M. F. of the dynamo being about 2,000 volts.

10. Describe the telephone and the transmitter.

MATERIALS OF CONSTRUCTION.

Examiner—MR. C. F. FINDLAY, M.A., M.I.C.E.

1. For what purposes are the following timbers used by engineers:—sâl, teak, ash, beech, greenheart, lignum vitæ?

2. What are the methods in common use for preserving timber, (*a*) exposed to sea water, (*b*) exposed to the weather in surface soil, (*c*) exposed to the weather above ground?

3. Give a brief specification for steel suitable for a rivetted girder bridge.

In what respects should it be altered in order to obtain a steel suitable for making rivets?

4. Describe the process of galvanizing iron. Why are galvanized iron sheets frequently corrugated?

5. Describe the chemical composition and process of manufacture of white lead.

6. What are the characteristics of good Portland cement?

7. A tidal dock is to be constructed in alluvial soil. What considerations would guide you in deciding between brick and concrete for the walls?

If concrete were used, what materials would be required, and in what proportions and manner are they to be combined?

8. In works of water-supply, pipes of cast-iron, of wrought iron and of lead are used. In what parts of the work would each kind of pipe be used and for what reasons?

9. What is the composition of the following alloys and for what purposes are they used:—gun-metal, soft solder, Babitt's metal, manganese bronze?

10. Describe briefly the manufacture of glazed stoneware pipes for drainage work.

GEODESY.

Examiner—RAI KRISHNA CHANDRA BANERJEE, BAHADUR, B.A.

1. Draw comparative scales $\frac{3}{500}$ to represent English feet, French metres, Greek cubits, 1 cubit = 0·45 metre.

2. Prepare a traverse table from the following data, and plot the survey to a scale of 200 feet = 1 inch:—

Section.	Observed inward angles.	Bearings.	Distances.
1		1 to 2 = 114° 10′	
2	225° 0′		238
3	112° 30′		370
4	100° 0′		362
5	129° 15′		595
6	112° 50′		268
7	143° 15′		346
1	83° 10′		351·5

3. A curve is to be laid out with a radius of ½ a mile to join 2 straight lines, one of which has been pegged out. The angle of intersection is observed to be 138° 27′. The tangent is calculated and laid off from the intersection; and the tangent point is found to lie between 353rd and 354th peg, and to measure 45·3 from the 353rd peg, the interval between pegs being 100 feet.

Find—

(1) the length of the tangent,
(2) ditto , of the secant,
(3) ditto of the curve,
(4) the 1st and 2nd odd distances,
(5) the number of the last peg on the curve,
(6) the first and second tangential angles.

4. If the above curve has been laid out as far as the 360th peg, and if it is found necessary to shift the theodolite to that peg, describe fully how you would fix the position of the 361st peg.

5. What is meant by the variation of the compass? Is it the same at all places? Does the variation increase or decrease annually? Give two simple methods of finding it.

6. Describe clearly and note in order the corrections you would apply, when an observation is made on the sun by an alt-azimuth instrument.

7. What do you understand by mean and sidereal times? Show how you would convert the one to the other, and *vice versâ*.

8. What is an astronomical triangle? Supposing the sides of the triangle and the hour angle of a star are known, show by a sketch how you would find the mean time of the observation.

ENGINEER DEPARTMENT.

List of Bachelors and Licentiates in Engineering of the Calcutta University.

	B.C.E.		Present or last appointment.
	Satcouri Chatterjee ...	1864	Sub-Engineer, Public Works Department, Bankipore.
	Umbica Charan Chowdhary ...	...	
	Ramrattan Mozoomdar ...	1868	
	Madhub Chandra Ray ...	1869	Retired.
5	Kali Podo Sen ...	1870	Retired.
	A. G. Bremner ...	1872	Dead.
	J. C. Rees ...	1872	Executive Engineer, Burma Ruby Mines.
	Netye Govindo Chowdhury ...	1873	District Engineer, Monghyr.
	Hari Das Pal ...	1875	District Engineer, Burdwan.
10	Nobin Chandra Gupta ...	1875	
	Sasi Bhusan Mitra ...	1875	District Engineer, Dacca.
	Ambica Charan Bose ...	1875	
	Mohendro Nath Sen ...	1876	Dead.
	Nagendro Nath Chatterjee ...	1876	
15	Asutose Lahiri ...	1876	District Engineer, Rangpur.
	Atul Krishna Mookerjee ...	1877	District Engineer, Dinajpur.
	Gagan Chandra Biswas ...	1877	District Engineer, Jalpaiguri.
	Behari Lal Rajack ...	1877	
	Jogodish Chandra Ray ...	1877	District Engineer, Lohardaga.
20	Suresh Chandra Ganguly ...	1878	Supervisor, Public Works Department.
	Bhut Nath Chattopadhyay ...	1879	Assistant Engineer, East Coast Railway, Madras.
	Upendro Nath Chattopadhyay	1879	Pleader, Monghyr Bar.
	Bama Charan Sen ...	1880	Supervisor, Public Works Department, Bengal.
	Surendro Kumar Bose ...	1880	Teacher, Civil Engineering College, Sibpur. Officiating as Professor of Drawing.
25	Upendro Nath Bandyopadhayay	1880	District Engineer, Birbhum.
	Annadaprosad Sircar ...	1883	Assistant Engineer, 1st grade, Public Works Department, Bengal.
	Hari Pada Ghosal ...	1883	Builder and Contractor, Calcutta.
	Rajendranath Mukhopadhyay	1883	Supervisor, Public Works Department, Bengal.
	B.E.		
	Sorabji Shavaksha ...	1886	Assistant Engineer, 1st grade, Public Works Department, North-Western Provinces and Oudh.
	Beni Madhab Mittra ...	1887	Assistant Engineer, Public Works Department, Bengal
	Nogendra Nath Mukhopadhyay	1888	Assistant Engineer, Public Works Department, Bengal.
	Satish Chandra Chattopadhyay	1889	Overseer, Public Works Department, Bengal.
5	Adhor Lal Chandra ...	1889	
	J. B. Godfrey ...	1890	Temporary Assistant Engineer.

	B.E.—*concluded.*	Year.	Present or last appointment.
	Po Thoung ...	1890	Unknown.
	Khirode Chandra Mukerjee ...	1890	Overseer, Public Works Department, Bengal.
	Haridas Ganguli ...	1890	Overseer, Public Works Department, Bengal.
10	Giris Chandra Das ...	1891	
	Mohini Mohan Lahiri ...	1891	Overseer, Public Works Department, Bengal.
	Modhusudhan Sen Gupta ...	1892	Assistant Engineer, Public Works Department, Bengal.
	Surendra Nath Bhattacharji ...	1892	Overseer, Public Works Department, Bengal.
	C. H. Bond ...	1892	Temporary Assistant Engineer, Madras.
15	Saroda Charan Mitra ...	1892	Overseer, Public Works Department, Bengal.
	Saroda Sundar Pal ...	1893	Assistant Engineer, Public Works Department, Bengal.
	Syama Charan De ...	1893	Overseer, Public Works Department, Bengal.
	Srish Chander Chuckrabarti ...	1894	Apprentice Engineer, Public Works Department, Bengal.
	Pores Charan Chatterjee ...	1894	Assistant Engineer, Public Works Department, Bengal.
20	Jotendro Nath Mullick ...	1894	Overseer, Public Works Department, Bengal.
	Kali Narayan Sen ...	1894	Overseer, Public Works Department, Bengal.
	Nilmoney De, B.A. ...	1894	Overseer, Public Works Department, Bengal.
	Amar Nath Das ...	1895	Apprentice Engineer.
	Jagat Bandhu Bagchi ...	1895	Overseer, Public Works Department Bengal.
25	Nogendra Nath Dutt ...	1895	
	Bhola Nath Banerjee ...	1896	Under Practical Training.
	Upendra Nath Dutt ...	1896	
	Prithiviraj Mukerjee ...	1896	
	Chuni Lal Sarkar ...	1896	
30	Chitta Sukh Sanyal ...	1896	
	Phani Lal Mallick ...	1896	
	Bejoy Krishna De ...	.....	
	Agnore Chandra Mukerjee ...	1896	
	L.C.E.		
	Raj Kishna Banerjee ...	1854	
	Kedar Nath Das ...	1864	
	Raj Krishna Coomar ...	1864	
	Ashutose Mitra ...	1864	
5	A. D. Atkinson ...	1865	
	Purno Chander Sarkar ...	1865	
	M. R. Lackerstein ...	1867	Executive Engineer, Public Works Department.
	Preo Nath Banerji ...	1867	Retired.
	Omerto Lal Ray Chowdhury ...	1867	Retired.
10	Unadi Nath Mookerjee ...	1867	Executive Engineer, Eastern Bengal State Railway.
	Khetter Nath Ghose ...	1867	Dead.

		Year.	Present or last appointment.
	L.C.E.—*continued.*		
	Bhuban Mohan Bose ...	1867	Executive Engineer, Bareilly, Rampur.
	Jogendro Nath Mookerji ...	1868	
	Kanti Chundra Banerjee ...	1868	Supervisor, Public Works Department, Bengal.
15	Prosonno Coomar Daniary ...	1869	Retired.
	Sandam Charn Patnaik ...	1869	
	Haran Chunder Banerjee ...	1870	Retired.
	Kally Prosonno Mookerji ...	1870	Deceased.
	Aghore Nath Mookerji ..	1870	
20	Gyan Chandra Ray ...	1870	
	Woolay Narayan Singh ...	1870	
	Rakhal Das Chatterji ...	1871	Retired.
	Kally Sunker Chatterji ...	1871	Executive Engineer, Public Works Department, Northern Bengal Railway.
	Kerty Chunder Chowdhury ...	1872	Retired.
25	Chander Mohan Ray ...	1872	
	Dhurroney Dhor Banerji ...	1872	District Engineer, Ghogipur.
	W. P. Milne ...	1872	Executive Engineer, B. B. M. Railway.
	J. R. Swinden ...	1872	Retired.
	Prosonno Kumar Pal ...	1872	Sub-Engineer, Public Works Department, Bengal
30	Troylukho Nath Banerji ...	1873	Supervisor, District Board, Muzaffarpur.
	F. M. D'Rozario ...	1873	District Engineer, Pabna.
	Herambo Nath Das ..	1874	District Engineer, Mymensingh.
	Bhut Nath Chuckerbutty ...	1874	Port Commissioners' Engineer, Calcutta.
	Preo Nath Ghose ...	1875	District Engineer, Tippera.
35	Kenaram Bose ...	1875	Municipal Engineer, Howrah.
	Mati Lal Ash ...	1875	Calcutta Municipality.
	Raj Krishna Das ...	1875	
	Giris Chandra Bhor ...	1875	
	Benay Krishna Bose ...	1875	District Engineer, 24-Parganas.
40	Durga Charan Chukerbutty ...	1876	Supervisor, Public Works Department, Bengal.
	Gopal Lal Banerji ...	1876	District Engineer, Birbhum.
	Kissori Mohan Mookerji ...	1876	District Engineer, Balasore.
	Giris Chundra Dutt ...	1876	
	Brindaban Chandra Pal ...	1876	
45	Benod Behary Pal ...	1877	District Engineer, Noakhali.
	Hari Charan Pal ...	1877	
	Jogendro Nath Ghose ...	1877	District Engineer, Backergunge.
	Prasanna Kumar Sen ...	1877	
	Benoy Krishna Mookerji ...	1877	
50	Purno Chandra Chatterji ...	1877	Sub-Engineer, Public Works Department, Assam.
	Kunjo Behary Bose ...	1877	
	Hari Das Chatterji ...	1878	District Engineer, Khulna.
	Nebaran Chandra De ...	1878	District Engineer, Mymensingh.
	Priya Krishna Biswas ...	1878	Supervisor, Public Works Department, Bengal.
55	Atul Chandra Bandyopadhyay	1880	District Engineer, Palamau.
	Nogendro Nath Bandyopadhyay	1880	Overseer, 1st grade, Public Works Department, Assam.

		Year.	Present or last appointment.
	L.C.E.—*concluded.*		
	Bhabadeb Chattopadhyay ...	1880	Contractor, Madras.
	Ashutosh Chattopadhyay ...	1880	District Engineer, Faridpur.
	Gopal Chandra Chattopadhyay	1880	Supervisor, Public Works Department, Bengal.
60	Abhoya Charan Dutt ...	1880	Calcutta Municipal Corporation.
	Jnanendro Nath De ...	1880	Out of employment.
	Bama Charun Mukhopadhyay	1880	
	Abinash Chander Roy ..	1880	Supervisor, Public Works Department, Assam.
	Radha Raman Guha ...	1880	Teacher, Dacca Survey School.
65	Satya Charan Bandyopadhyay	1881	Engineer, private service.
	Lalit Mohan Basack ...	1881	Out of employ.
	T. B. Byers ...	1881	District Engineer, Malda.
	P. W. Byers ...	1881	Teacher, Civil Engineering College.
	Pran Krishna Sen ...	1881	Supervisor, Public Works Department.
70	Bhushan Chandra Bandyopadhyay.	1882	Supervisor, 1st grade, Public Works Department, Bengal.
	Sita Prasanna Roy ...	1882	Supervisor, Public Works Department, Bengal.
	Hari Prosad Ghosal ...	1883	Supervisor, Public Works Department, Bengal.
	J. A. Martin ...	1883	Public Works Department, India Government.
	C. P. Warde ...	1883	Executive Engineer, Public Works Department, Bengal.
75	Akhil Chandra Marik ...	1885	Deceased.
	Banku Behari Mukhopadhyay	1885	Supervisor, Public Works Department, Bengal.
	L.E.		
	W. A. E. Hanby ...	1885	Assistant Engineer, Public Works Department, Bengal Railways.
	Hpo Thine ...	1886	Assistant Engineer, Public Works Department, Burma.
	H. E. W. Martindell ...	1888	Assistant Engineer, Public Works Department, Burma.
	Hari Charan Mukhopadhyay ...	1888	Teacher, Civil Engineering College.
5	Surendro Nath Barat ...	1888	Overseer, Public Works Department, Bengal.
	V. B. Webber ...	1888	Temporary Assistant Engineer, Burma.
	Nabakumar Chakrabarti ...	1889	District Engineer, Bogra.
	Gyanendro Nath Gangopadhyay	1889	District Engineer, Howrah
	Krisnadhone Bandyopadhyay	1889	Overseer, Public Works Department, Bengal.
10	Kalibar Bhattacharyya ...	1889	Deceased.
	Rajendro Nath Mukhopadhyay	1889	Overseer, Public Works Department, Bengal.
	W. S. Bremner ...	1889	Assistant Engineer, 3rd grade.
	Sarat Chander Sen ...	1889	Assistant Surveyor, Surveyor-General's Office.
	Trailokya Nath Mazumdar ...	1890	Overseer, Public Works Department, Bengal.
15	Nagendra Nath Mitra ...	1890	Temporary Assistant Engineer, Burma, Public Works Department.

	L E.—*concluded.*	Year.	Present or last appointment.
	F. F. Bion ...	1890	Assistant Engineer, Burma.
	Mahendra Nath Dutt ...	1890	Assistant Engineer, Public Works Department, Bengal.
	Jadu Nath Das ...	1890	Overseer, Public Works Department, Bengal.
	Bankim Krishna Ghose ...	1890	Overseer, Public Works Department, Bengal.
20	Abdul Rahman ...	1890	Unknown.
	G. J. St. C. Sedgley ...	1891	Assistant Engineer, Public Works Department, Bengal.
	Satyaranjan Khastgir ...	1891	Overseer, Public Works Department, Bengal.
	Upendra Nath Mukhopadhyay	1891	Overseer, Public Works Department, Bengal.
	Ahindro Chandra Mukhopadhyay.	1892	Assistant Engineer, Burma.
25	Anango Mohon Pal ...	1892	Overseer, Public Works Department, Bengal.
	Amullya Krishna Bhattacharjee	1893	Overseer, Public Works Department, Bengal.
	Baidya Nath Chatterjee ...	1893	Overseer, Public Works Department, Bengal
	Sarat Chandra Sur ...	1893	Overseer, Public Works Department, Bengal.
	Pyari Charan Gupta ...	1894	Overseer, Public Works Department, Bengal.
30	Ronesh Chander Das ...	1895	Under practical training in the East Indian Railway Colliery, Giridhi.
	Manmatha Kumar Bosu ...	1895	Overseer, Public Works Department, Bengal.
	Jadub Chander Talapatra ...	1895	
	Sarbaranjan Lahiri ...	1896	Under Practical Training.
	Nanda Lal De ...	1896	
35	Kedar Nath Mazumdar ...	1896	

N.B.—Any inaccuracies in the above list should be brought to the notice of the Principal. Passed students out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any student getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

ENGINEER DEPARTMENT.

SCHOLARS AND MEDALLISTS.

Forbes' Memorial Scholars.

1880	Bhusan Chandra Bandyopadhyay. Kali Gopal Rudra.
1881	Not awarded.
1882	C. P. Warde. Hari Pada Ghosal.
1883	W. A. E. Hanby.
1884	Tarak Chandra Ghose. Hpo Thine.
1885	Not awarded.
1886	H. E. W. Martindell. Hari Charan Mukhopadhyay.
1887	Nogendra Nath Mukhopadhyay. Rajendra Nath Mukhopadhyay.
1888	Adhor Lal Chandra. W. S. Bremner.
1889	Mohindra Nath Datta. Haridas Gangopadhyay.
1890	Giris Chandra Das. Modhu Sudan Sen Gupta.
1891	Ahindra Chandra Mukhopadhyay. Amullya Kristo Bhattacharjee.
1892	Syama Charan De. Pyari Charan Gupta.
1893	Bassanto Kumar Sen. Srish Chandra Chakrabutty.
1894	Amar Nath Das. Ronesh Chandra Das.
1895	Bhola Nath Bannerjea. Prithiraj Mukerjea.
1896	Asutosh Guha. Kissorie Mohan Ghose.

Sibley Mining Scholars.

1895 Ronesh Chandra Das.

Ambika Charan Chaudhuri Medallists.

1880 Upendro Nath Bandopadhyay.

1881, 1882 Not awarded.

1883 Rajendra Nath Mukhopadhyay.

1884, 1885 Not awarded.

1886 Sorabji Shavaksha.

1887 Beni Madhab Mittra.

1888 Nogendro Nath Mukhopadhyay.

1889 Satish Chandra Chattopadhyay.

1890 Khirode Chandra Mukhopadhyay.

1891 Giris Chandra Das.

1892 Madhusudhun Sen Gupta.

1893 Syama Charan De.

1894 Nilmoni De, B.A.

1895 Amar Nath Das.

1896 Bhola Nath Banerji.

Trevor Medallists.

1891 Mohini Mohan Lahiri.

1892 Ahindra Chandra Mukhopadhyay.

1893 Saroda Sundar Pal.

1894 Sris Chandra Chakarvarti.

1895 Amar Nath Das.

1896 Upendra Nath Dutt.

List of passed students who obtained guaranteed appointments as Assistant Engineers, Public Works Department.

1885	Annoda Prosad Sarcar. C. P. Warde.
1886	W. A. E. Hanby.
1887	Sorabji Shavaksha.
1888	Beni Madhub Mittra.
1889	Nagendro Nath Mookerji. H. E. W. Martindell.
1890	W. S. Bremner.
1891	F. F. Bion. Mohendro Nath Dutt.
1892	G. J. St. C. Sedgley.
1893	Ahendro Chander Mookerji. Modhu Sudhan Sen Gupta.
1894	Saroda Sundar Pal.
1895	Sris Chander Chakravarti. Poresh Charan Chatterji.
1896	Amor Nath Das.

CIVIL ENGINEERING COLLEGE, SIBPUR.

APPRENTICE DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the College and Workshops, including the regulation of the course of study, theoretical and practical, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects.

Rules for Admission.

3. For admission to the Apprentice Department, candidates must be at least 15 and not more than 17 years of age.*

They must have passed Standard VII of the Code for European Schools, or the University Entrance Examination. They must submit their applications accompanied by a certificate of age and a certificate showing that they have passed the requisite standard, so as to reach the Principal not later than the 6th January of each year. No applications will be attended to after this date.

4. The number to be admitted each year is limited to 60.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, chest measurement, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Before an apprentice is admitted to the College, his parent or guardian must sign an agreement in the form shown in Appendix A.

7. The session begins on the first Monday in February. All apprentices are required to join the College on that date. Any apprentice prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No apprentice will be admitted or re-admitted to the College after the close of the month of February, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. There will be a long vacation from about the middle of August to the end of October. Every apprentice must leave the College

* The age as given in the Calcutta, or other University certificate, is the only one accepted.

during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

9. The full course of instruction in this class will extend over five years, during the first three and-a-half of which the instruction will be both theoretical and practical. The last year and-a-half will be spent entirely in practical work. For details of the course of study, *see* Appendix B.

10. Every apprentice who passes the annual examination held at the end of the second year will be entitled, on leaving the College, to a certificate, stating that the holder possesses the theoretical qualifications required of a sub-overseer in the Public Works Department.

11. An apprentice who passes the final examination held at the end of three years and-a-half will be entitled to a third-grade Overseer's certificate.

12. On the completion of his practical course, an apprentice will be entitled to a first or second-grade Overseer's certificate, according to the estimate formed of his work by the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. No apprentice who at the end of three years and-a-half leaves the College with a third-grade Overseer's certificate will at any future time be allowed to return for his practical course.

14. Every apprentice who leaves the College after the expiration of the five years' course will receive a certificate in the form shown in Appendix C, provided that he has attended the Workshops on 80 per cent. of working days during the last 18 months of his apprenticeship.

[NOTE:—

Extract from the "Calcutta Gazette" of the 16th March 1887, page 79, Part IB.

A candidate for employment on the Subordinate Engineering Staff of the District Engineer must be qualified in one of the manners following, that is to say:—

(1) If the pay of the appointment is Rs. 60 per mensem, or more, he must hold—

(*a*) a certificate from the Principal of the Government Engineering College at Sibpur that he has served his apprenticeship there and passed the final examination qualifying him for employment in the Public Works Department as a Foreman Mechanic or an Upper Subordinate.]

15. Apprentices will attend in the class-rooms and in the Workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year.

16. All apprentices will be required to reside on the College premises, so far as the accommodation will permit.

FREE AND REDUCED FEE LIST.

17.* European or Eurasian apprentices, up to the number of 25, are received into this department on payment of Rs. 5 a month for the twelve months of the year. The cost of messing is estimated at Rs. 20 a month. In the case of these 25 apprentices, the balance, viz., Rs. 15 a month, will be paid to the mess fund by

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, and of Government pensioners, who, when on active service, were liable to be so employed, are admissible to the reduced fee-list.

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the session to those apprentices who may have joined the College, none can be guaranteed beforehand. Forms to be filled up for the consideration of the Board are supplied on application.

Government. In addition, five such apprentices are admitted free. Thus the total of free apprentices and apprentices on a reduced fee will be 30.

18. Europeans and Eurasians in excess of that number will be received as apprentices into the College, so far as the accommodation will permit, on paying the full cost of their messing, viz., Rs. 20 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, taken at two months and-a-half, a charge of Rs. 2 a month will be made to defray the cost of maintaining mess servants.

19.* Native apprentices up to the number of 40 will be received into the Apprentice Department on payment of Rs. 2 a month for the twelve months of the year. The cost of messing is estimated at Rs. 7 a month. In the case of these 40 apprentices, the balance, viz., Rs. 5 a month, will be paid to the mess fund by Government.

20. Native apprentices in excess of this number will be received into the College on paying the full cost of their mess, viz., Rs. 7 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, reckoned at two months and-a-half, a charge of Re. 1 a month will be made to defray the cost of superintendence and mess servants.

Stipends.

21. After the final examination, 10 stipends of Rs. 10 and 10 of Rs. 6 each, tenable for one year and-a-half, will be awarded to those apprentices who pass the best examination, both theoretical and practical.

Standing Orders for Students.

22. Every resident European apprentice will join the European mess. On joining the mess, every apprentice will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table linen, &c. A list of breakages and other damage done will be prepared monthly, and each apprentice will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if an apprentice has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

23. Hindu apprentices must ordinarily join the College mess for Hindus, and abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal are admissible to the reduced fee-list

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the session to those apprentices who may have joined the College, none can be guaranteed beforehand. Forms to be filled up for the consideration of the Board are supplied on application.

24. Each resident apprentice must provide his own clothing and bedding and a bedstead. No furniture may be brought into the College without special permission.

25. All payments must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting apprentice's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines.

26. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

27. All breaches of discipline committed by any apprentice will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

28. A Conduct Register of each apprentice will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

29. Apprentices are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(*i*) Disobedience of orders.
(*ii*) Absence without leave.
(*iii*) Idleness.
(*iv*) Insubordination or disrespect to the College or Workshop authorities.

30. Apprentices may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal should be reported to the Director of Public Instruction, and any fees paid by the apprentice shall be forfeited.

31. Every apprentice will be responsible for any machines, tools, or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

32. A certain number of the apprentices will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly.

33. Any monitor may be removed by the Principal for misconduct or for inefficiency in the discharge of his duties.

34. No resident apprentice will ordinarily be allowed to keep a private servant.

35. On Sundays all resident Christian apprentices, Protestant and Roman Catholic, will be required to attend the services held in their respective chapels.

36. All apprentices will be required, while in the Workshops, to wear a uniform dress.

37. Leave will be granted by the Principal only. No leave will be granted except on a written application.

38. No resident apprentice may leave the College premises without the written orders of the Principal, whether on special leave or on a general holiday.

39. All European apprentices will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

40. One appointment is guaranteed yearly to apprentices of the College. The selected man is posted as Overseer, third grade, in the State Railways on the non-pensionable establishment.

41. All apprentices are obliged to join the College Athletic Club, the subscription to which is Rs. 3 per annum and the entrance fee Re. 1.

APPENDIX A.

CIVIL ENGINEERING COLLEGE, SIBPUR.

Memorandum of the conditions under which _____ *is admitted as a Mechanical Apprentice to the Civil Engineering College, Sibpur.*

1. He will be subject to the regulations set forth in the Rules of the Apprentice Department.
2. He will pay his own travelling expenses to Sibpur.
3. He will be on probation for six months; at the end of which time, if it appears that he is not physically fit for the work, or if for any reason (other than misconduct) it appears inexpedient to retain him, he will be sent back to his friends at the expense of Government.

4. The undersigned_

will for five years, beginning from the date of admission to the College, provide _____

with suitable clothes and the books required in his class; and will pay in advance to the Principal of the College, on or before the 15th of each month, the sums stated in Rules 17, 18, 19, 20, 22, 23, and 24. He will also make arrangements for the removal of _____

from the College during the long vacation under Rule 8, or any other time when required by the Principal.

5. In consideration of the foregoing conditions,

will be fed and lodged for a period of five years (excluding vacations), and will receive such instructions as will qualify him for employment as an Upper Subordinate in the Public Works Department and as a Foreman Mechanic.

6. Employment is not guaranteed after completion of apprenticeship.

Signature of parent or guardian. _____

Address. _____

Signature of witness. _____

Address. _____

Signature of the Principal, Civil Engineering College, Sibpur.

_____

Dated the day of 189 .

APPRENTICE DEPARTMENT.

List of Books to be procured by Apprentices.

Students will provide themselves with the following books:—

First year	Arithmetic	...	Charles Pendlebury's.
	Euclid	...	Hall and Steven's.
	Algebra	...	Hall and Knight's Elementary Algebra.
	Mensuration	...	Todhunter's.
	Engineering	...	Elementary "Building, Construction, and Drawing," by Edward J. Burrel.
	Drawing	...	Linear Drawing (Davidson's).
Second year	Trigonometry	...	Hamblin Smith's.
	Surveying	...	Roorkee papers.
	Estimating	...	Roorkee examples.
	Drawing	...	Projection (Davidson's).
Third year	Kinetics and Kinematics.		Blaikie's Dynamics.
	Physics	...	Balfour Stewart's.
	Chemistry	...	Remsen's.
	Masonry	...	Roorkee papers.
	Roads	...	
Fourth year	Statics	...	Blaikie's Dynamics.
	Hydrostatics	...	
	Physics	...	Balfour Stewart's.
	Steam-engine	...	Jamieson's.
	Mechanism	...	Tate's.
	Applied Mechanics		Roorkee Simple Applied Mechanics.
	Buildings	...	Roorkee papers.

APPENDIX B

Course of Study for the Apprentice Department.

	First year, Feb. to Aug.	Second year, Nov. to Aug.	Third year, Nov. to Aug.	Fourth year, Nov. to Aug.
	1	2	3	4
Mathematics ...	Arithmetic, the whole. Euclid, Books III, IV, VI, and definitions of V. Hall and Knight's Elementary Algebra to end of Chapter XXVII, and Mensuration to Chapter on Surfaces.	Algebra to end of ratio and proportion. Trigonometry. Mensuration.	(Blaikie's Dynamics) Kinematics and Kinetics.	(Blaikie's Dynamics) Statics and Hydrostatics.
Engineering ...	Burrel's Building construction	Estimating; Building materials.	Masonry; Estimating, Roads.	Applied Mechanics, Mechanism and the Steam engine, Buildings, Bridges.
Natural Science	.....	.....	Chemistry; Heat ...	Electricity and Magnetism.
Surveying ...	.....	Surveying with chain and prismatic compass, and Levelling.	Plane Table, Box-sextant, Theodolite and Levelling.	Laying out curves, and Field work generally.
Drawing ...	Printing, Scales, Geometrical drawing.	Orthographic projection ...	Engineering and Machine drawing.	Sketching and Machine drawing.

CIVIL ENGINEERING COLLEGE, SIBPUR.

APPRENTICE DEPARTMENT.

Full Course Certificate.

CERTIFIED that _____ years _____ months, was a student in the Apprentice Department of the Civil Engineering College, Sibpur, from _____ 189 __ to _____ 189 __, and passed the Final Examination qualifying him for employment in the Public Works Department as an Upper Subordinate or Foreman Mechanic.

Apprentice appeared at the Final Examination held in _____ 189 __.

Subject.	Full marks.	Marks obtained.	Division.	REMARKS.
Monthly Examinations ...				
Mathematics				
Natural Science				
Surveying				
Drawing				
Engineering				
Ditto (Practice Course) ...				
Total ...				

Apprentice has spent time in the shops as follows :—

Shops.	Months.	Proficiency.
Carpenters'		
Blacksmiths'		
Moulders'		
Fitters'		

Apprentice held the post of Monitor for _____ months.

Apprentice's character is as follows as regards the qualities mentioned :—

I.—Truthfulness ... ...
II.—Industry ... ...
III.—Energy ... ...
IV.—Obedience ... ...

General remarks _____

SIBPUR ; *Principal.*

The . 189 .

APPRENTICE DEPARTMENT.

WORKSHOP COURSE.

Workshop Hours—Junior Apprentices, 8—11; Senior Apprentices, 8—11 and 12-30—4.

First Year.

Carpenters' Shop.—Apprentices are made acquainted with and shown how to use and handle properly the tools ordinarily employed for the purposes of carpenters' and joiners' work. They are taught the method of preparing wood, setting out, and forming the various joints. The practical application of the foregoing instruction is brought to bear by employing them in making tools, boxes, doors, windows, roof trusses and other framings required for buildings, and other engineering works.

Second Year.

Blacksmiths' and Boiler-makers' Shop.—Apprentices are taught to use and handle correctly the different tools, to lay and manage the fires, to draw down, bend, jump, weld, split, punch, chamfer, and temper. After this they are set to make small forgings of tools, bolts, nuts, hooks, and shackles, and also of parts of trusses, as well as other forgings of parts of machines. In the boiler-makers' shop they are familiarised with the use of rivetting tools and the process of rivetting, and learn to punch and shear correctly with the machines for that purpose.

Third Year.

Vicemen and Fitters' Shop.—The apprentices are put through a course of chipping, filing, and fitting so as to gain experience in the tools used by this class of workmen, after which they make up various tools required in the fitters' shop, and assist in ordinary fitting work. Those who prove themselves sufficiently proficient are then put on as attendants to the workmen employed on the different machines so as to acquire a knowledge of lathe-work, such as facing, surfacing, turning, boring, and screw-cutting, and also shaping, drilling, slotting, and planing in the machines used for these purposes. They thus gain confidence in using these machines so as to be entrusted to work them by themselves.

EXAMINATIONS.

Annual examinations are held at the end of the first, second, and third years. Each apprentice has to produce within a given time certain tasks allotted him bearing upon the instruction received during the course of the year.

Fourth Year.

Foundry or Moulding Shop.—Only six months of the apprentice's time is devoted to this shop. They learn to use the various moulder's tools, to mix foundry sand and loam, to make moulds from patterns supplied, and are shown how to ensure good work and clean castings. They are also taught how to prepare and charge the cupolas. An insight into the nature of the wooden patterns required for forming the moulds being thus obtained, they are set to work with the pattern-makers to make patterns, from which they are expected to produce castings.

EXAMINATIONS.

At the end of the three and-a-half years the apprentices having gone through the various shops have a final examination, and in a given time have to produce pieces of work requiring the use of the different tools used in the respective shops, to show that the skill acquired by them has been maintained, and that they show sufficient mechanical aptitude to be considered fit to complete their apprenticeship. During the three and-a-half years theoretical instruction in the College and practical training in the Workshops are simultaneously carried on, but during the remaining one and-a-half years they are solely employed in the shops, and are designated "senior apprentices."

Fourth and Fifth Years.

Senior Apprentices—Are employed independently on the lathes, drills, shaping, slotting, planing, punching, shearing, and screwing machines, and are taught to set out and mark off work for them, these machines being brought into use to make tools, machines, parts of engine and pump fittings, and any other instructive work that may be going on in the shops. They assist generally in the repairs to the hulls and machinery of launches, also in repairs to portable engines, centrifugal, donkey, and other pumps. They are taught to make steam joints, pack glands, set valves, and get up steam and drive engines so as to be competent to take charge of (as well as carry out any necessary repairs to) portable or fixed engines and boilers or a steam-launch. They are also instructed in laying out work to full size on the drawing boards, from drawings, for the use of the workmen.

Form of application to be filled in by a candidate for admission to the Apprentice Department, Civil Engineering College, Sibpur.

I desire to be admitted to the Apprentice Department, Civil Engineering College, Sibpur, and enclose:—

(*a*) Certificate of having passed the Entrance Examination of the Calcutta University, or the 7th Standard of the European Schools.

(*b*) An attested certificate of age.

(*c*) Name, address and occupation of father or guardian.

Signature of applicant.

Dated *189* .

Note.—If this form is not properly filled up, no notice will be taken of the application.

APPRENTICE DEPARTMENT.

MONTHLY EXAMINATION.

March 1896.

4th year.

1. What is Electrical Induction? Describe what happens when a body is charged by Induction. Given that a glass rod rubbed by silk is positively charged, show how to determine with the aid of the Electroscope the nature of a charge on any other body.

Describe and explain the action of Thomson's Replenisher, giving a diagram.

2. Define Potential, and explain how it is measured. Find an expression for the potential of a condenser consisting of two concentric spheres separated by a layer of insulating material, the radii being a and b.

3. Find the point of application, direction, and magnitude of two parallel forces, P and Q, acting at points A and B.

4. From a square a portion is cut off by a line passing through the middle points of two adjacent sides. Find the centre of gravity of the remainder.

5. Given a freehand sketch with index of Newcomen's engine. Describe in your own words its action, and how you would start it.

6. Describe in your own words the several effects which take place in succession on applying heat to a lump of ice enclosed in a cylinder.

Distinguish between saturated steam, dry saturated steam, and superheated steam.

7. Explain the meaning of the following terms:—

Reciprocating rectilinear motion, reciprocating curvilinear motion, angular velocity, receivers, communicators and operators of a machine, modulus of a machine.

8. What do you understand by the term Principle of virtual velocities. Explain its meaning clearly by an example from any machine you know.

9. Define—Load, line load, stress, strain, proof and working loads, factor of safety, modulus of fracture and modulus of elasticity. Name the principal modes of application of load with their principal subdivisions.

10. The section of an iron bar 20 feet long is $3'' \times \frac{3}{4}''$. It bears a weight of 25 tons. Find the elongation, the modulus of elasticity being 29,000,000 lbs.

11. A cylindrical boiler 7′ 6″ in diameter has to sustain a pressure of 90 lbs per square inch. Compute the requisite thickness of wrought-iron plates, taking 10 as the factor of safety. The tensile strength of double rivetted plates is 48,000 lbs.

12. The iron composing the links of a chain is $\frac{1}{8}''$ in diameter. If the chain is broken by a stress of $4\frac{1}{2}$ tons, what amount of tenacity does the iron indicate? Express your answer in tons per square inch.

3rd year

1. Explain the following:—Ashlar, coursed rubble masonry, common rubble masonry, block-in-course, bond, racking back, pisè walls, inverts, relieving arches, intrados, spandrels, voussoirs.

2. Describe how bricklayer's scaffolds are made. Why should they not be loaded heavily? If it is required to load them heavily, what precautions are to be taken?

3. Describe a centering with sketches. What are the chief points to be attended to in all centerings?

4. In any triangle show that—

(*a*) $a = b \cos. C + c \cos. B.$

(*b*) $\tan. \frac{A-B}{2} = \frac{a-b}{a+b} \cot. \frac{C}{2}.$

5. If $A + B + C = 180^c$ show that—

(*a*) $\text{Cos.}^2 A + \cos.^2 B + \cos.^2 C + 2 \cos. A \cos. B \cos. C = 1.$

(*b*) $\text{Cos. } A + \cos. B = \frac{a+b}{c} 2 \sin.^2 \frac{C}{2}.$

6. (*a*) Given log. 60195 = 4·7795532.
log. 60196 = 4·7795604.

Find the number whose logarithm is 2·7795561.

(*b*) Given L cos. 29° 25′ = 9·9400535.
L cos. 29° 26′ = 9·9399823.

Find the angle whose L cos. is 9·9400512.

7. Describe a maximum and a minimum thermometer, pointing out the use of such thermometers, how they are set, and how read.

Convert 84° F. into C. & R.

8. Define the coefficient of expansion, linear and cubical. Prove that the coefficient of cubical expansion is three times the coefficient of linear expansion.

A steel rectangular block measures 30c. by 50c by 10c. at 64°C. Find its volume at 40°C. Coefficient of linear expansion = ·0000116.

9. In what respects do gases differ from solids and liquids in regard to expansion?

Prove that for gases $\frac{VP}{1+\alpha t}$ = constant.

10. What is an element and a compound? What is chemical action? What three kinds of chemical action are there? What is meant by the term "burning"? Describe an experiment which shows that when a candle burns there is no loss of weight.

11. Describe the preparation of oxygen, and show how the gas can be stored for experimental purposes. (This involves a description of the gas-holder.)

12. Describe Kipp's apparatus for obtaining a constant supply of a gas.

Suppose you had vessels of O, H, NH_3, N, N_2O, N_2O_2; how would you distinguish these various gases from each other?

2nd year.

1. Figure (*a*), Plate IV is a section of a double floor carried by rolled-iron joists. Show a plan to the same scale, the floor-boards being removed. The common joists are 12″, and the ceiling joists 14″ apart from centre to centre.

2. Figure (*b*), Plate IV is a plan of a floor in which the girders are rolled-iron joists 10″ × 4½″ and the binders of wood 9″ × 6″ resting on the top of the girders, and carrying 6″ × 3″ bridging joists, and 1½″ floor board, 7″ wide. Give a section through AA, showing the construction.

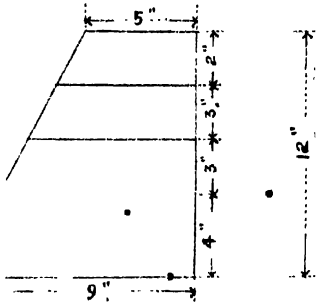
3. Give sketches showing the difference between a double floor with rolled girders and a floor consisting of rolled girders, binders, and bridging joists.

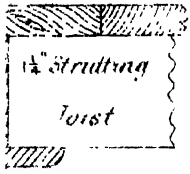
4. Show by sketches the difference between single, double, and framed floors, giving the names of the different parts.

5. Figure (*c*), Plate IV is a plan of a double floor showing position of girders. Give a section through AA, showing rolled-iron girders 5″ × 10″, bridging joists 8″ × 2½″, floor battens 7″ × 1½″, and ceiling joists 4″ × 2″.

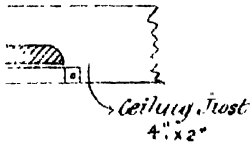
6. Construct a scale of 8 inches to 1 mile to read to 20 paces, and by a vernier to 5 paces. One pace = 30 inches.

7. A person observes the elevation of a tower to be 60°. On receding from it 100 yards further, he finds the elevation to be 30°. Required the height of the tower.





10"x 1" R.I.J.



8. Prove the following relations—

(*a*) $\cos x\,(2\sec x + \tan x)\,(\sec x - 2\tan x)\quad 2\cos x - 3\tan x.$

(*b*) $\sec\theta + \operatorname{cosec}\theta \cdot \tan^3\theta\,(1 + \operatorname{cosec}^2\theta) = 2\sec^3\theta.$

9. (*a*) Find the value of $\dfrac{1+x}{1+\sqrt{(1+x)}} + \dfrac{1-x}{1-\sqrt{(1-x)}}$ when $= \dfrac{\sqrt{3}}{2}$.

(*b*) Extract the square root of $7-4\sqrt{3}$.

10. (*a*) If $x+7 : 2\,(x+14)$ in the duplicate ratio of 5 : 8. find x.

(*b*) If $\dfrac{a}{b} = \dfrac{e}{f}$, show that $\dfrac{2a^4\,b^2+3a^2\,e^2-5e^4\,f}{2b^6+3b^2f^2-5f^5} \quad \overline{b^4}$

11. A box without a lid is made of wood an inch thick; the external length, breadth, and height of the box are 2 feet 10 inches, 2 feet 5 inches, and 1 foot 7 inches respectively. Find what volume the box will hold.

12. If a rectangular parallelopiped has its length, its breadth, and its depth respectively, a quarter as large again as another rectangular parallelopiped, show that the first is nearly twice as large as the second.

April.

4th year.

1. What is diamagnetism? Mention the magnetic substances. What is the molecular theory of magnetism? Draw a diagram indicating the magnitude and direction of the lines of force in the arrangement of magnets in Figure (*d*), Plate VI. What is declination? What is inclination?

2. What is the cause of the enfeeblement of the current in a simple voltaic cell? Show how this cause is removed in the following cells:—Volta, Grove, Smee, Bichromate, Callan.

3. Describe the Danish steel-yard and show how it may be graduated. Draw a diagram of a system of pulleys such that W=31P.

What is the angle of repose, and what connection has it with the coefficient of statical friction?

4. A true balance has one scale unjustly loaded; if a body be successively weighed in the two scales and appear to weigh P and Q lbs. respectively, find the amount of the unjust load, and also the true weight of the body.

5. Classify pillars according to their manner of failure under compression or according to the values of the ratio $l \div d$. Explain how the best form of pillar is usually attained.

6. Determine the external diameter of a cast-iron hollow column 10 feet high to carry a dead-weight of 10 tons, the ends to be flat and firmly fixed, and the weight over the centre of the column; the thickness of the metal to be $\frac{1}{12}$ of the external diameter. Factor of safety is 4, resistance to crushing of cast-iron is 80,000 lbs. per square inch, and the value of the constant in Gordon's formula is $\frac{1}{6400}$.

7. What would be the height of a stone pillar, specific gravity 2·5, the lower blocks of which would be crushed under its own weight? The ultimate resistance to crushing of stone is 5,000 lbs. per square inch.

8. Find graphically the stresses in the members of a symmetrical triangular truss of 16 feet span and 4 feet rise, on which the total load is 8,000 lbs.

9. Make a diagram to illustrate the four principal points of admission, cut-off, release, and compression in the motion of the simple D slide valve, as well as the corresponding positions of the crank, and also the probable distribution of steam in the cylinder or diagram of work.

10. In a single slide-valve gear the travel of slide is 4·6 inches and the angle of advance 30°, and cut-off of steam takes place while the piston travels 0·8 of its stroke, and exhaustion of steam begins when the piston has still 0·04 of its stroke to travel. Find inside and outside lap and lead, and maximum opening of ports.

11. Required the velocity ratio of the power and weight in the system of rods represented in Figure (*e*), Plate IV, when AC=5, CB=2, BQ=6, QD=3, DR=7, and RE=1.

12. What must be the difference between the diameters of the axles in a compound wheel and axle, so that the velocity ratio of P and W may be 100, when the length of the handle is 2½ feet?

3rd year.

1. Into vessels containing chlorine throw (*a*) powdered antimony, (*b*) phosphorus, (*c*) copper foil heated, (*d*) red cloth, (*e*) blotting paper soaked in oil of turpentine. Describe what happens, and point out what is formed in (*a*), (*c*), (*e*). Why is chlorine gas a good disinfectant?

2. What is an acid, alkali, metal, salt? Mention the principal acids and bases, and give three equations showing the reaction between acids and bases, selecting different acids and bases for each reaction.

3. Describe the forms in which carbon is found in nature? Can either be prepared artificially? Mention the different kinds of amorphous carbon, pointing out their uses. Describe completely the preparation of carbon monoxide.

4. What are liquefaction, solidification, regelation, vaporisation, evaporation, ebullition, sublimation? Describe and explain a simple experiment showing that the boiling point varies with the pressure. What other things affect the boiling point?

5. What is the difference between radiation, conduction and convection? What is the thermal diffusivity of a substance? Describe an experiment on the thermal diffusivity of iron and bismuth.

6. Describe the safety lamp. For what purpose is it used, and why is it safe?

Describe the freezing of a lake.

7. Describe the method of sinking well foundations in India.

8. Sketch and describe a cofferdam.

9. Give a short explanation of sheeting, bearing and screw piles. Where are they generally used?

10. In any triangle if $\cos A \cos B \sin C = \frac{\sin A + \sin B}{\sec A + \sec B}$, show that $C = 90°$.

11. Solve the following right-angled triangles, C being the right angle:—

(*a*) Given $b = 3$, $c = 5$, and sin. 53° 7′ = ·7998593
sin. 53° 8′ = ·8000338.

(*b*) Given $b = 273$, $c = 785$, log b = 2·4361626, log c = 2·8948697, log 736 = 2·8668778, log 1058 = 3·0244857, log 2 = ·3010300.

L cos 69° 38′ = 9·5416126
L cos 69° 39′ = 9·5412721.

12. A person observes the angle of elevation of a hill to be 32° 14′, and on approaching 500 yards nearer he observes it to be 63° 26′. Find the height of the hill, having given—

tan 32° 14′ = ·63, tan 63° 26′ = 1·998.

2nd year.

1. Explain the meaning of the following terms:—Templates, wall plates, head, sill, door-head, straining beam, quarters or studs, and nogging pieces.

2. Explain by sketches the difference between common partitions, trussed partitions, and brick-nogged partitions.

3. Show by sketches how to arrange the sill of a partition so as to prevent its projecting above the floor-boards across a door-opening.

4. A room 14′ wide is to be divided in two by a quarter partition. It is to rest on 4½″ × 3″ plates, which carry the floor joists on brick offsets. Give an elevation of the framing of the partition, showing a central opening 7′ × 3′ for a door. The scantlings, which are to be marked on the different members, are to be as follows: sill 4″ × 4″, studs 4″ × 2″, braces 4″ × 2″, door-studs 4″ × 3″.

5. The scantlings of a framed partition carried on two 14″ brick walls 15′ apart with a 3′ doorway at the side are as follows:—Sills

4″ × 3″, studs 4″ × 2″, door-studs 4″ × 4″, braces 4″ × 2″. Give an elevation of the partition, marking the scantlings on the different parts, the bottom sill to rest on stone corbels and the top sill to run into the walls.

6. Draw the elevation of a trussed partition with side-door spaces for carrying the floor above. The span or width of the room is 20 feet.

7. Prove the following relations :— (*a*) $\cos(90° + A) = -\sin A$; (*b*) $\frac{\cos A - \cos 3A}{\sin 3A - \sin A} = \tan 2A$.

8. Find the values of (*a*) sec $(-135°)$, (*b*) cosec $(-690°)$, (*c*) sin 1485°.

9. Solve the equations:—(*a*) $\sin\theta + \cos\theta = \sqrt{2}$; (*b*) $\sin\theta - \cos\theta = \sqrt{\frac{3}{2}}$.

10. Show that (*a*) $\cos(A - B) = \cos A . \cos B + \sin A . \sin B$; (*b*) $\tan 75° = 2 + \sqrt{3}$.

11. Every edge of a certain triangular prism measures 10 inches. Find the volume.

12. The volume of a ring is 800 c. inches, the radius of cross section is 2″. Find the length of the ring.

1st year.

1. Find the value of 11·236 of $\frac{15}{16}$ of £2 + $\frac{2\frac{1}{5}}{2\frac{2}{10}\frac{8}{1}}$ of 2·04752 of 8*s*. 4*d*.

2. Find by Practice the value of 14*a*. 3*r*. 26$\frac{2}{3}$*p*. at £52 7*s*. 6*d*. per acre.

3. Five men working 8 hours a day take 20 days to pave a road 440 yards long and 35 feet broad. How many days will six men, three of whom work 8 hours and three 10 hours a day, take to pave a road 1,575 yards long and 36$\frac{1}{2}$ feet broad?

4. Solve—

$$\frac{\cdot 25\,(x-3) + \cdot 3\,(x-4)}{\cdot 125} = 5x - 19.$$

5. I bought a certain number of apples at three a penny, and five-sixths of that number at four a penny. By selling them at sixteen for six pence, I gained 3$\frac{1}{2}$*d*. How many apples did I buy?

6. Solve—

$$\frac{3}{x} + \frac{5}{y} = \frac{8}{15}$$
$$9y - 22x = \frac{3xy}{25}$$

7. Describe a square that shall be equal to a given rectilineal figure.

8. The square on any straight line drawn from the vertex of an isosceles triangle to the base is less than the square on one of the equal sides by the rectangle contained by the segments of the base.

9. If a straight line drawn through the centre of a circle bisects a chord which does not pass through the centre, it shall cut it at right angles, and, consequently, if it cuts it at right angles, it shall bisect it.

10. What are the characteristics of good timber?

11. Describe the qualities of good bricks, and compare brick with stone as a building material.

12. Mention some methods devised for increasing the durability of building stone. How would you use stone of laminated structure in building?

MAY.

4th year.

1. Describe and explain the tangent galvanometer. Why is it so named? State the laws regulating the action of currents on currents.

2. Explain the equation $C = \frac{E}{B + R}$. Show how to arrange a battery of cells so as to produce the greatest effect (1) when the external resistance is small compared with the internal, (2) when it is large.

3. Describe with a diagram Bramah's press. A solid which is lighter than water weighs 5 lbs., and when the solid is attached to a piece of metal the whole weighs 7 lbs. in water; the weight of the metal in water being 9 lbs. Compare the specific gravities of the solid and of the water.

4. When a body of uniform density floats in water, show how its specific gravity may be determined.

A diving-bell is lowered until the surface of the water within is 66 feet below the outer surface. State approximately how much the air is compressed. If a small hole be made in the top of the diving-bell, will the water flow in or the air flow out?

5. Explain the difference between isothermal, saturation, and adiabatic expansion of steam, and draw roughly the curves of each in one diagram.

6. What is meant by the term "clearance"? Assuming that the clearance has been reduced to an equivalent length of the stroke of piston, which is 4 feet, and taking the case where steam is cut off at half stroke, the clearance being 3 inches, you are required to compare the pressure of the steam when 3 feet of the stroke are made, with the pressure under the same circumstances if there were no clearance.

7. Find the diameters of a set of five speed pulleys, which shall produce a series of velocity ratios in the axes, corresponding to numbers 5, 2, 1, ½, and ⅓, the constant sum of the diameters being 12 inches.

8. Name the different forms of wheel-work communicating motion from one axis to another (1) when the axes are parallel to each other, (2) when they are at right angles to each other, and (3) when they have got any inclination. Sketch a pair of wheels of the last form, whose radii are 3 inches and 2 inches, and whose axes are at an angle of 60° to each other.

9. Find graphically the stresses in all the parts of an ordinary king-post truss with span 30 feet and rise $\frac{1}{3}$ of the span. The trusses are placed 10 feet apart, and the weight of the roof covering is 10 lbs. per square foot.

10. Show that a beam of rectangular section, intended for transverse strain, can, for economic purposes, be changed into one of I cross section.

11. A flat balcony $20' \times 2\frac{1}{2}'$, weighing 25 lbs. per square foot, and liable to carry a steady load of 75 lbs. per square foot, is to be carried on 5 sal cantilivers fixed in a wall. Find their scantling. $p_b = 750$ $s = 10$.

Reproduce Hodgkinson's formula for supported iron beams, explaining the notation used.

12. Find the sectional area at the middle of a flange required for two wrought-iron guiders of I shape carrying a bridge of 25 feet clear span, weighing 1 ton per foot run, and liable to a live load of 1 ton per foot run.

$$S = 5,\ A_c = 2A_t,\ C = 74.$$

3rd year.

1. What is the difference between a hypothesis and a theory? What is the atomic theory?

Define valence, and state the valence of H, Br, O, S, N, K, Fe. Into what two great classes are all elements divided? What is meant by families of elements? Give the members of the following families: chlorine, sulphur, nitrogen.

2. From what substance is iodine obtained? Describe the complete process. Give the properties of iodine. Describe the process of etching on glass.

3. Give the properties of sulphur. What happens when H_2S is passed into solutions of lead nitrate, zinc, sulphate, arsenic trioxide? What is the difference between the bleaching action of chlorine and sulphur dioxide? How would you mix H_2SO_4 and water? Why is H_2SO_4 an important substance? Define monobasic and dibasic acids, and acid, neutral and normal salts.

4. Define specific heat, atomic heat, latent heat. How can specific heat be determined by the method of cooling? Explain the equation $M(T-\theta)S = m(\theta - t)s$.

5. Find the specific heat of a substance 90 *gm.* of which at 150°C. when immersed in 300 *gm.* of water at 20° give a resulting temperature of 30°.

6. Find the result of mixing 5 parts of snow at —16° C and 12 parts of water at 30° C.

7. A straight road over an uneven and hilly country may at first view, when merely seen on the map, be pronounced to be a bad one. Explain the above.

Show how steeper gradients are allowable on kutcha than on pucka roads.

8. What is the primary object of metalling the road surface?

Give a short description of the various road metals that are used in Bengal.

9. Give specification with cross section of a first-class road in the province of Rajputana.

10. Prove the ambiguous case geometrically. When $C = 30°$ $b = 16$, $c = 8$, is the triangle ambiguous or not?

11. Solve the triangles for which the following parts are given:—

(*a*) $a = 320$, $A = 66° 2' 52''$ $C = 90°$

(*b*) $a = 379{\cdot}5$, $b = 564{\cdot}8$, $A = 40° 32' 16''$.

12. Each of two ships, half a mile apart, finds the angles subtended by the other ship and a fort to be respectively 85° 15′ and 83° 45′. Find the distance of each from the fort.

2nd year.

1. Explain the meaning of the following terms as used in the construction of wood-roofs: span, pitch, principal rafters, king-posts, common rafters, ridge-board, purlins, pole-plates and gutter plate.

2. Draw the elevation of a collar beam roof truss for a span of 20′, rise $\frac{1}{3}$ span, with the names and scantlings of different parts.

3. Give a sectional elevation of a little more than half a king-post roof-truss, resting on 14″ brick walls 20 feet apart, taking the following scantlings: wall plates $4\frac{1}{2}'' \times 3''$, tie beam $9'' \times 3''$, principals $6'' \times 3''$, struts $3'' \times 3''$, king-post $4'' \times 3''$, heel strap and stirrup iron 2″ wide.

4. Draw from the following details an elevation of a roof-truss for a 25′ span: tie beam $4'' \times 10''$, principals $5'' \times 4'$, struts $4'' \times 2''$, king rod $\frac{3}{4}''$ round iron.

5. Give an elevation of a trussed-rafter roof-truss for a span of 20′, rise $\frac{1}{4}$ span, with necessary details and scantlings of different parts.

6. Draw skeleton diagrams showing the difference between a king-post and queen-post roof-truss, writing the names against the different members.

7. Prove by diagram that $\tan (A-B) = \frac{\tan A - \tan B}{1 + \tan A - \tan B}$.

8. Show that :—(*a*) $\frac{\tan A - \tan B}{\tan A + \tan B} = \frac{\sin (A-B)}{\sin (A+B)}$; (*b*) $\tan 50^\circ \cot 50^\circ = 2 \sec 10^\circ$.

9. If $a : b :: p : q$, then $a^2+b^2 : \frac{a}{a+b} :: p^2+q^2 : \frac{p^3}{p+q}$.

10. If x and y be unequal, and x have to y the duplicate ratio of $x + z$ to $y + z$, prove that z is a mean proportional between x and y.

11. The faces of a pyramid on a square base are equilateral triangles, a side of the base being 120 feet. Find the volume.

12. The slant side of the frustum of a right circular cone is 5 feet, and the radii of the ends are 7 feet and 10 feet. Find the volume.

1st year.

1. A person by selling goods which cost £14 per cwt. at 2*s.* $9\frac{3}{4}d.$ per lb. makes 5 per cent. more profit than he would have done if he had sold the goods for £55 15*s.* $3\frac{3}{4}d.$ What was the amount sold?

2. Find the simple interest on £1271 4*s.* $5\frac{1}{4}d.$ for 327 days at $7\frac{3}{8}$ per cent.

3. A man walks 35 miles partly at the rate of 4 miles an hour and partly at 5. If he had walked at 5 miles an hour when he walked at 4 and *vice versâ*, he would have covered two miles more in the same time. Find the time he was walking.

4. Find the square root of $-3a^3 + \frac{25}{9} + a^4 - 5a + \frac{61}{12}a^2$.

5. Solve $\cdot 0\dot{8}\dot{3}\ (x - \cdot 625) = \cdot 0\dot{9}\ (x - \cdot 59375)$.

6. The opposite angles of any quadrilateral inscribed in a circle are together equal to two right angles.

7. A triangle is inscribed in a circle. Show that the sum of the angles in the three segments exterior to the triangle is equal to four right angles.

8. If two chords of a circle cut one another, the rectangle contained by the segments of one shall be equal to the rectangle contained by the segments of the other.

9. To what uses are the following put: cast-iron, wrought-iron, steel, copper, lead, zinc, concrete and quick-lime?

10. Describe with sketches the following: queen closer, king closer, bond, hoop-iron bond, footings, damp-course, corbels, offsets, jambs and sills.

11. Sketch a segmental arch and name its different parts.

12. Print in italics: To draw a circle of a given radius which shall touch another given circle and a straight line.

JUNE.

4th year.

1. Define calorimetry, British thermal unit. Describe briefly with a diagram Bunsen's ice calorimeter. What is meant by thermal capacity? The specific heat of platinum being ·033, how much at the temperature of 280° F. will be sufficient to raise 20 lbs. of water from 42° to 70°?

2. Define saturated steam, dry saturated steam, superheated steam. State the essential differences between jet and surface condensers. Steam enters the condenser at a temperature of 183° F. The temperature of the hot-well is 120°, the condensing water enters at a temperature of 60°. Find the amount of condensing water required per pound of steam (1) with a jet condenser, (2) with a surface condenser, the discharged water being at a temperature of 100°.

3. A heavy particle is projected with a velocity V in a direction making an angle θ with the horizon. Find expressions for (1) time of flight, (2) greatest height, (3) horizontal range. At what angle must the particle be projected so that (1) the greatest height, (2) the horizontal range is a maximum?

4. When any body is moving with uniform velocity in a straight line, what do we know concerning the forces acting on it?

What constant horizontal force is required to stop a train of 120 ton mass running at 60 miles an hour (1) in 2 minutes, (2) in 300 yards?

5. A beam 40 feet span supports four loads of 5, 1, 2 and 3 tons, situated at distances of 10, 18, 32, and 36 feet, respectively, from the left abutment. Find the maximum bending moment, and where it occurs. Also draw the shearing stress diagram.

6. In the above question draw the curve of bending moments by a purely graphical method, and show how the bending moment at any point can be obtained.

7. One end of a rectangular beam of oak, 10 feet long, 4 inches wide and 6 inches deep, is fixed in a wall. What load distributed over its length will break it, the co-efficient of rupture of oak being 5 tons?

8. A wrought-iron girder of I section rests on two abutments placed 60 feet apart, and is uniformly loaded with 1 ton per lineal foot, including the weight of the girder. Find the sectional area of the flanges if the depth of the girder is 10 feet. The safe resistance to compression and tension of wrought-iron is 4 and 5 tons, respectively.

9. Describe Richard's indicator, and point out precisely the mechanism by which the pencil is actuated, giving the reason for the special construction. The barrel of such an indicator is 2 inches in diameter, and it vibrates through $\frac{3}{4}$ of revolution. The area of the diagram is $3\frac{1}{2}$ square inches, and the indicator pencil moves 1 inch for 30 lbs. variation in pressure, the diameter of piston = 18 inches, stroke = 2 feet. Find the I. H. P. when the engine is making 50 revolutions per minute.

10. Describe a method of obtaining the brake horse-power of an engine, and state the advantages to buyer and seller of adopting this method over that of nominal or indicated horse-power. An engine is making 150 revolutions per minute, the diameter of the brake pulley being 4 feet, and the pull on the brake 50 lbs.; what is the B. H. P.?

11. What is the meaning of the term cam? Find the form of the cam that will give three upward and three downward strokes to a rod moving through a length of 3 inches, the velocity ratio of the handle and the rod being constant.

12. What is a swash plate? What will be the length of the stroke of a swash plate when the distance of the rod from the ends is 3 inches, and the plate has an inclination of 45° to the direction of its axis?

3rd year.

Compare the properties of ordinary and red phosphorus. Form the salts of orthophosphoric acid with the following metals:—Calcium (dyad), silver (monad), iron (triad), tin (tetrad).

How is arsine prepared? Give the formula of borax. What minerals contain silicon dioxide?

2. What would a thorough study of each metal include? To what elements is the name metal usually given? How is potassium iodide prepared? Give its properties. Give Leblanc's method for making soda. Under what circumstances was it devised?

3. What is lime? How is it prepared? What happens when lime is treated with water? What is mortar? What takes place when mortar is exposed to the air? What promotes this action? Give the flame reactions of K, Na, Ca, Sr, Ba. If the K flame is masked by the Na. flame, what is done to get over the difficulty?

4. (*a*) Find the specific heat of a substance 95gms., of which at 14,° when immersed in 250gms. of water at 15,° give a resulting temperature of 25°.

(*b*) Find the result of mixing 29 parts of water at 7° with 35 parts at 16°.

5. Lead melts at 326°. Its specific heat is ·0314 in the solid and ·0402 in the liquid state. Find what mass of copper at 0° will be raised 5° by pouring on it 300 gms. of melted lead at 380°; specific heat of copper = ·0949.

6. A litre of alcohol measured at 0° C. is contained in a brass vessel weighing 120 gms., and after being raised 60° is immersed in a kilogramme of water at 12° contained in a brass vessel weighing 210 gms. The temperature of the water is thereby raised to 30°. What is the specific heat of alcohol? Specific gravity of alcohol is ·8; specific heat of brass is ·1.

7. Describe fully the contents of the report of a complete road project, and mention the drawings that are to accompany such a report.

8. Describe fully the method of consolidating a road surface metalled with broken stone.

9. (*a*) Find the area of a regular polygon in terms of its sides.

(*b*) Find the radius of a circle inscribed in a triangle in terms of the sides of the triangle.

10. In any isosceles triangle, C being the vertical angle, show that area $\times$ 32 Cos.$^{-1}\frac{A}{2} = \text{Sin}_{\cdot}2A \times (2a+c)^2$.

11. Enunciate and prove the proposition known as the parallelogram of velocities.

12. A man swims across a river with a velocity of 3·6 feet per second, and the velocity of the current is 10·5 feet per second. If the river be 972 feet broad, find how far the man is carried down by the current.

2nd year.

1. Draw the skeleton diagram of a king rod roof truss with struts, the details of the joints and members to be shown.

2. Draw the line diagram of a queen rod roof truss, and give details of the joints at the feet of the main struts and of the joint at the head and foot of a queen rod.

3. Draw complete in all its details the elevation of a trussed rafter roof truss with one strut.

4. Give an elevation of a little more than half of a trussed rafter roof truss with three struts.

5. Give details of the joints at the feet of the rafters and struts of the roof truss in question 4.

6. Fignre (*f*), Plate IV is a line diagram of an ordinary iron roof truss. Give sections of the parts A, B, C, D, E, and a sketch of any method you know of for connecting these pieces together.

7. Prove that —(*a*) $\cos 2A = 2\cos^2 A - 1 = 1 - 2\sin^2 A = \cos^2 A - \sin^2 A$.

(*b*) $\text{Cos } 3A = 4\cos^3 A - 3\cos A$.

(*c*) $\tan 3A = \frac{3\tan A - \tan^3 A}{1 - 3\tan^2 A}$

8. Prove the following relations:—(*a*) $\text{Cot}(45° - A) = \sec 2A + \tan 2A$.

(*b*) $\text{Cot } B = \text{cosec } 2B + \cot 2B$.

9. Show that:— (*a*) $\frac{\cos 3\theta - \sin 3\theta}{\sin\theta + \cos\theta} = 1 - 2\sin 2\theta$.

(*b*) $\text{Cot}^2(45° + \frac{A}{2}) = \frac{2\,\text{cosec } 2A - \text{Sec } A}{2\,\text{cosec } 2A + \sec A}$

10. The base of a prism is an equilateral triangle, each side of which is 4 inches; find the volume of the solid obtained by cutting of a piece of this prism, so that the sum of the parallel edges is 42 inches.

11. The ends of a prismoid are rectangles, the corresponding dimensions of which are 12 feet by 10 feet and 8 feet by 6 feet; the height of the prismoid is 4 feet; the prismoid is divided by a plane parallel to the ends and midway between them. Find the volume of each part.

12. The radius of the base of a cone is 4 inches. Find the height, so that the volume may be equal to that of a sphere with diameter 4 inches.

1st year.

1. What sum lent at compound interest will amount to £933 6*s*. 8*d*. in 2½ years at 2½ per cent.?

2. At what rate per cent. will the interest on £3,729 7*s*. 6*d*. due 4 years hence be equal to the discount on £4,661 14*s*. 4½*d*. for the same time?

3. Solve $(a - b)\,x + (a + b)\,y = 2a^2 - 2b^2$
$(a + b)\,x - (a - b)\,y = 4ab.$

4. A man spends £5 in buying two kinds of silk at 4*s*. 6*d*. and 4*s*. a yard. By selling it all at 4*s*. 3*d*. per yard he gains 2 per cent.; how much of each did he buy?

5. In a given circle to inscribe a triangle equiangular to a given triangle.

6. A B C D E is a regular pentagon, and AC, BE intersect at H. Show that (1) AB = CH = EH; (2) AB is a tangent to the circle circumscribed about the triangle BHC; (3) AC and BE cut one another in medial section.

7. The parallel sides of a trapezoid are respectively 8 feet and 14 feet. Two straight lines are drawn across the figure parallel to these, so that the four are equidistant. Find the lengths of the straight lines.

8. The perimeter of a semi-circle is 100 feet; find the radius.

9. What is meant by natural bed, hammer dressed, and chisel draft stones, and underpinning?

10. Sketch a scarf joint well adapted to resist tension and compression, and another to resist transverse strain.

11. What is meant by dovetail halving, notching, cogging, and wedging? Give sketches.

12. Within the given square ABCD to inscribe the largest equilateral triangle it will contain.

JULY.

3rd year.

1. What is the value of the unit of heat in ——? When a gas expands against pressure, why does its temperature fall? Draw the diagram of the cylinder and piston of a double-acting steam-engine. What is the resultant force on the piston? What is the difference between a high-pressure and low-pressure engine?

2. Show how to convert potassium chromate into dichromate and dichromate in chromate. How can you show that the chromates are good oxidising agents?

Give the formulæ of alum, iron alum, and chrome alum. How would you test a sample of water for lead in solution?

3. Give the oxides of lead. If red lead be treated with nitric acid, what takes place? Give the equation of the reaction when lead peroxide is treated with hydrochloric acid.

How would you distinguish between stannous and stannic compounds?

Give the properties of gold and platinum.

4. A rectangular block of brass has the following dimensions at 60° centigrade; length = 40 cm., breadth = 15 cm., depth = 10 cm. What are its dimensions and volume at 25°? Co-efficient of linear expansion = ·0000188.

5. 146 ccm. of air at 72°C and 480 mm. occupy what volume at 39° and 600 mm?

6. (*a*) Find the result of mixing 35 parts of ice at 15° and 5 parts of steam at 200°.

(*b*) Find the specific heat of a substance 100 gm. of which at 160°, when immersed in 300 gm. of water at 15°, give a resulting temperature of 25°.

7. What are zigzags? Discuss their general adoption.

8. Describe the construction of a cliff gallery with sketch.

9. Show by sketches how the common rafters are trimmed and the lead gutter formed at the back of a chimney penetrating a sloping roof.

10. A local train makes its run of 13 miles and back once in every two hours, stopping half a minute at each of 14 intermediate stations, and 10 minutes at either terminus. What is its average velocity when in motion?

11. Enunciate the first two laws of motion and the law of Gravitation. Define inertia, mass and momentum.

12. A well is 559 feet deep. Find approximately the time which will elapse between dropping a stone into the well and hearing the sound of the splash. Take the velocity of sound as 1,118 feet per second.

2nd year.

1. Give half inside and half outside elevation of a venetian window, with an inside elevation of the style and a vertical section through the valves.

2. Draw the inside elevation of a glazed window with folding sashes, giving a vertical section through one of the sash-bars.

3. Give half inside and half outside elevation of an ordinary panel window with four leaves.

4. Explain, by sketches, the construction of a solid framed window with centre-hung sash.

5. Figure (*g*), Plate IV is a plan showing the rolled-iron cross girders of a floor running into the main girders over the head of a column. Draw a section through AB, showing in elevation the head of a column, the mode of attaching the cross girders to the main girders, and the main girders bolted to the column.

6. Show how to find the distance of an inaccessible object by means of a rhombus.

7. The diameter of a sphere is 18 feet; the sphere is divided into two segments, one of which is twice as high as the other. Find the volume of each.

8. A pyramid on a regular hexagonal base is trimmed just enough to reduce it to a cone. Show that rather less than $\frac{1}{10}$ of the original volume is removed.

9. Solve the equation (*a*) $\text{Sin } 2\theta + \sqrt{3} \cos 2\theta = 1$; (*b*) $\tan 2a = 3 \tan a$.

10. From 2·483269 take $\bar{3}$·742891. (*b*) Divide $\overline{14}$·432962 by 6.

11. (*a*) Given log 2=·3010,300; find $\log \left(\frac{5^{90}}{2^{40}}\right)^{\frac{1}{75}}$. (*b*) Solve the equation $a^x b^{mx} = c^{1-3x}$.

12. On a given straight line describe a segment of a circle, containing an angle equal to a given rectilineal angle.

1st year.

1. Find the alteration in income occasioned by shifting £3,200 stock from the 3 per cents. at 86⅜ to 4 per cents. stock at 114⅛, the brokerage being ¼th per cent. on each transaction.

2. A, B, and C are partners; A receiving ⅖ths of the profits, and B and C sharing the remainder equally. A's income is increased £220 when the profits rise from 8 to 10 per cent. Find the respective capitals invested.

3. Solve $x^2 - xy + y^2 = 76.$

$x + y = 14.$

4. Triangles which are equal in area, and which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional. Conversely, triangles which have one angle of the one equal to one angle of the other, and the sides about these angles reciprocally proportional, are equal in area.

5. Each side of a rhombus is 24 feet, and one of the diagonals also is 24 feet: find the area.

6. The sides of a triangle are 13, 14, and 15 feet. Find the perpendicular from the opposite angle on the side of 14 feet.

7. The radius of a circle is one foot. Find the area of a regular polygon of eight sides inscribed in the circle.

8. Sketch a four-panel door, naming its several parts. How are the parts put together?

9. Explain how the several joints are made in the above door, with sketches.

10. Describe the following panels, with sketches: moulded and flat, flush, solid, and raised.

11. Inscribe a square in a regular pentagon.

12. Construct a scale of 8 miles to an inch to read furlongs. What is the representative fraction?

APPRENTICE DEPARTMENT.

ANNUAL EXAMINATION, AUGUST 1896.

ARITHMETIC AND ALGEBRA.

1st, 2nd, and 3rd years.

1. Simplify—

$$1\ \frac{1}{11}-\frac{1-\frac{7}{22}}{2-\frac{1}{3}}+\frac{1\frac{2}{5}}{3\frac{1}{3}}-\frac{5\frac{5}{8}}{6\frac{1}{4}}\ \text{of}\ \text{“}\left(\frac{1}{5}-\frac{\frac{1}{2}-\frac{1}{3}}{4\frac{2}{3}-3\frac{2}{9}}\right)-\frac{3}{7}.$$

2. (*a*) Divide ·0063612 by 2·052; (*b*) find the sum of $2\cdot4\dot{1}\dot{8}$, $1\ 1\dot{6}$, $3\cdot0\dot{0}\dot{9}$, $\cdot7354$, 24·042; (*c*) express the sum of $\cdot8\dot{3}$ of 13*s.* 4*d.* and $\cdot13\dot{8}$ of £1-4 as the decimal of £5.

3. Find by Practice the value of 11 cwts. 3 qrs. 23 lbs. at £4-5-6 per cwt.

4. In what time will £1,275 amount to £1,549-11 at $3\frac{1}{5}$ per cent. per annum?

5. Find the discount on a bill of £368-8 drawn 9th September 1875 at three months and discounted on 5th October of the same year at 5 per cent.

6. Resolve into factors (*a*) $4a^2+28a+49$; (*b*) $50x^3-32xy^4$; (*c*) $x^2+y^2-z^2+2xy-2z-1$; (*d*) $x^8+x^4y^4+y^8$.

7. Find the H. C. D. and L. C. M. of $x^3-x^2-10x-8$, $x^3+6x^2+11x+6$, $x^3+4x^2-11x-30$.

8. Extract the square root of (*a*) $16-6\sqrt{7}$; (*b*) $9-24a-68a^2+112a^3+196a^4$.

9. Simplify $\dfrac{\sqrt{2}\,(2+\sqrt{3})}{\sqrt{3}\,(1+\sqrt{3})}-\dfrac{\sqrt{2}\,(2-\sqrt{3})}{\sqrt{3}\,(\sqrt{3}-1)}$.

10. Solve (*a*) $\dfrac{3x+7}{14}-\dfrac{2x-7}{21}+2\frac{3}{4}=\dfrac{x-4}{4}$.

(*b*) $\left.\begin{aligned}3x-2y&=7\\xy&=20\end{aligned}\right\}$.

(*c*) $x^2+2\sqrt{x^2+6x}=24-6x$.

GEOMETRY AND MENSURATION.

[1st year—Omit 11 and 12; 2nd and 3rd years—Omit 6 and 9.]

1. In a right-angled triangle the square described on the hypotenuse is equal to the sum of the squares described on the other two sides.

2. If a straight line be divided equally, and also unequally, the sum of the squares on the two unequal parts is twice the sum of the squares on half the line and on the line between the points of section.

3. If two chords of a circle cut one another, the rectangle contained by the segments of one shall be equal to the rectangle contained by the segments of the other.

4. Describe a rectilineal figure which shall be equal to one and similar to another rectilineal figure.

5. If from any external point P two tangents are drawn to a given circle, whose centre is O, and if O P meets the chord of contact at Q, then the rectangle O P, O Q is equal to the square on the radius.

6. (*a*) The chord of half an arc is 2 feet 6 inches, and the diameter of the circle is 4 feet 2 inches; find the chord of the arc.

(*b*) The perimeter of a semi-circle is 100 feet; find the radius.

7. The side of a square is 85 yards, and a path 10 yards wide goes round the square outside it; find how many stones, each 1 foot 4 inches long by 10 inches wide, will be required to pave the path.

8. Each side of a rhombus is 32 feet, and each of the larger angles is equal to twice each of the smaller angles. Find the area.

9. The radius of a circle is 15 feet; find the area of the two parts into which it is divided by a chord equal to the radius.

10. The carpeting of a room twice as long as it was broad at 5 shillings per square yard cost £6-2-6, and the painting of the walls at 9*d.* per square yard cost £2-12-6; find the dimensions of the room.

11. Find the number of cubic feet in a regular hexagonal room, each side of which is 20 feet in length and the walls 30 feet high, and which is finished above with a roof in the form of a hexagonal pyramid 15 feet high.

12. A bowl is in the shape of a segment of a sphere; the depth of the bowl is 9 inches, and diameter of the top of the bowl is 3 feet; find to the nearest gallon the quantity of water the bowl will hold.

TRIGONOMETRY.

[2nd year—Omit 11 and 12; 3rd year—Omit 2 and 9.]

1. Explain the different methods that are usually adopted for the measurement of angles.

One of the angles of a quadrilateral is 60°, another is 50 grades, and a third is equal to three-fourths of two right angles; express all the angles in degrees.

2. Prove the following:—

(*a*) Cos x + Sin x tan x = Sec. x.

(*b*) Cot$^2 d$ — cos^2 d = cot$^2 d$ cos$^2 d$.

3. From the top of a hill there are observed two consecutive milestones on a horizontal road running from the base. The angles of depression are found to be 45° and 30°. Find the height of the hill.

4. Find the general value of θ, which satisfy the following equations:—

(*a*) 2 sin θ = tan θ; (*b*) tan^2 θ + 4 Sin^2 θ = 3.

5. Prove the following:—

(1) Sin (A + B). Sin (A—B) = Sin^2 A — Sin^2 B.

(2) 2 sin $(x + y)$ cos $(x—y)$ = sin 2 x + sin 2y.

6. Prove that—

(*a*) $\dfrac{\text{Sin } A - \sin B}{\text{Cos } B - \cos A} = \cot \dfrac{A + B}{2}$.

(*b*) Cos θ — cos 5 θ = 2 sin 3 θ sin 2 θ.

7. Show that sin (180° + A) = — sin A and sin (90° + A) = cos A.

8. Find the value of sin 3A and cos 3A in terms of sin A and cos A respectively

9. Show that the logarithm of a product is equal to the sum of the logarithms of its factors.

10. Solve:--(1) $a^{3x} b^{4-x} = c^{2x-1}$.

(2) $\dfrac{4^x}{2^{x+y}} = 8$ & $x = 3y$

11. Prove the following for a triangle:—

(1) $\dfrac{\text{Sin } A}{a} = \dfrac{\sin B}{b} = \dfrac{\sin C}{c}$.

(2) $\dfrac{c-a}{c+a} \cot \dfrac{B}{2} = \tan \dfrac{C-A}{2}$.

(3) $b \cos^2 \dfrac{C}{2} + c \cos^2 \dfrac{B}{2} = s$.

12. Show how to solve a triangle completely when two sides and the included angle are given.

Two sides of a triangle are to each other as 9 : 7 and the included angle is 64° 12′; determine the other angles, having given—

log 2 = ·30103. L tan 57° 54′ = 10·2025255.

L tan 11° 16′ = 9·2993216, L tan 11° 17′ = 9·2999804.

DYNAMICS.

3rd year.

1. Define motion, speed, uniform speed, variable speed. When is the speed of a point called its velocity? State and prove the polygon of velocities.

2. Find the resultants of the following pairs of velocities at an angle of 60° (*a*) 10 and 3$\sqrt{2}$, (*b*) 2 and 2$\frac{1}{2}$, (*c*) $4x + 2$ and $2x$ $(3x + 2)$.

3. A boat is rowed in the direction of right across a river with a velocity of six miles an hour. The river has a velocity of five miles an an hour, and is two miles broad. Find how far the boat will be carried down by the time it reaches the opposite bank and the time it takes to reach it.

4. Define acceleration. A stone is thrown vertically upwards with a velocity of 128 feet per second; find the greatest height and the time of reaching it. After how long will the stone be half way on its descent?

5. A particle whose initial velocity is 16 feet per second moves for 5 seconds under a uniform acceleration, and acquires velocity of 21. Find the acceleration, the average velocity, and the space described.

6. Define force, and state when a force is determined. Define inertia, mass, momentum, unit force. Explain the equation $w = mg$.

7. A stone weighing 5 lbs. is dropped from a balloon at rest and reaches the earth after 18 seconds. Find the momentum with which it strikes the earth and the height of the balloon.

8. Define energy, work, foot-pound, foot-poundal, horse-power.

A turbine of 15 horse-power transforms 60% of the energy of a waterfall into useful work. If the height of the fall be 150 feet, find what weight of water falls per second.

9. Show how the behaviour of the common pendulum illustrates the principle of the conservation of energy.

CHEMISTRY.

3rd year.

[Equations should be given wherever possible. Make your answers short, and give clear sketches of all apparatus mentioned.]

1. What is oxidation? Give three examples of oxidation, one at the ordinary temperature and two at a red heat, and give equations representing the chemical reactions taking place.

2. Find the amount of lead theoretically obtainable by the reduction of 1 cwt. of pure galena.

3. Calculate the percentage composition of pure marble.

4. How would you prepare chlorine gas (*a*) on the small scale, (*b*) on the large scale, for making bleaching powder?

5. How much gaseous hydrogen chloride would be required to produce 500 c.c. of hydrogen (measured under the same conditions), and how could you obtain the hydrogen from a given quantity of dry hydrogen chloride?

6. What is an acid, an alkali, a base, a salt? Give examples.

7. How may the presence of carbon dioxide in the air be detected? What volume of carbon dioxide at 760 m.m. and 0°C. weighs 440 grams?

SURVEYING.

2nd and 3rd years.

1. Construct the following scales:—

   (*a*) $\frac{1}{253440}$ to show miles and furlongs;
   (*b*) a diagonal scale of $\frac{1}{264}$ to read to fee

2. How do you—

   (*a*) Test the accuracy of a measuring chain
   (*b*) Make it of correct length?

3. Describe in full detail how to avoid an obstacle in a chain line, and to pick up the correct chainage on passing it.

4. Describe how you would conduct a chain-and-prismatic compass survey of a plot of ground like the College compound

5. Explain the permanent adjustments of an ordinary dumpy level.

6. Why is it an invariable rule when levelling along the centre line of a proposed road that readings must be taken at the end of every chain?

7. In running a line of levels between two bench marks the instrument was set up three times and the following readings were taken:—

   1st setting up, 4·56 on B.M. 6·1, 7·4, 11·2, 8·51;
   2nd setting up, 7·31, 5·2, 9·4, 0·5, 6·47;
   3rd setting, up 10·82, 9·7, 6·4, 3·26 on B.M.

Rule a field-book and enter above readings. Find out the difference of level between the two B.M.'s and give full arithmetical checks.

8. Show two ways of calculating the area included in a complete circuit of five lines.

9. The main horizontal scale of a theodolite is divided directly to $\frac{1}{3}$ degrees; show how to construct a vernier to read to $\frac{1}{3}$ minutes.

10. Obtain an expression for the error due to curvature of the earth. How is this altered so as to allow for refraction?

What is the greatest distance from which a light 100 feet high is visible at sea to an observer standing on the deck of a ship 16 feet out of water? Illustrate by a diagram. Diameter of earth = 42,000,000 feet.

[2nd year to answer 1, 2, 3, 4, 5, 6, 7; 3rd year to answer 2, 5, 6, 7, 8, 9, 10.]

PHYSICS.

3rd year.

1. What do you mean by saying that—

(*a*) the specific heat of platinum is 0·0314;
(*b*) the heat of combustion of carbon is 8080;
(*c*) the maximum pressure of aqueous vapour at 25°C is 23·55 mm. of mercury?

2. What is the theoretical efficiency of a reversible engine which works between 350°F. and 50°F?

3. The mechanical equivalent of heat is 778, if the pound, the foot, and the Fahrenheit degree are the units used. What is its value, taking as units the kilogram, the metre, and the metigrade degree?

1 metre = 39·37 inches, 1 kilogram = 2,205 lbs.

4. The heat of combustion of a certain kind of coal is 7250. How much water can be evaporated from and at 100°C by one cwt. of that coal, if one-third of the heat is lost by radiation, convection, and conduction?

5. Clearly distinguish between radiation, convection, and conduction of heat.

6. State the laws of fusion.

7. In what engineering problems would you have to take account of the expansion of solids?

ENGINEERING.

1st, 2nd, and 3rd years.

1. What do you understand by the term "hydrauliсity of lime," and on what does it depend? Distinguish between quicklime, hydraulic lime, and hydraulic cement. What is mortar? How is it prepared and used?

2. For what purposes are the following metals used in building construction: cast-iron, wrought-iron, copper, lead, and zinc?

3. What are the points that you should have in view in forming timber joints? What are housed-tenon, tusk-tenon, oblique tenon, and stub-tenon? Give a sketch of each.

4. Draw freehand the following joints and mark on them the scantling of timbers:—Wall plates $4\frac{1}{2}'' \times 3''$ at the angle of a building by halving, bridging joist $8'' \times 2\frac{1}{2}''$ with a binder $14'' \times 11''$ by notching; joint in the tie beam by fishing, tie-beam $13'' \times 18''$; joint in the same tie beam by scarfing.

5. Show by sketches the difference between coursed rubble masonry and rubble masonry built up to courses.

6. Figure (*h*), Plate IV is the outside elevation and section of the front wall of a brick house. Draw the same, adding a string course, window sills, and cornice with blocking course, all made of stone.

7. What is the use of footings in the foundation of a wall? What rules should be observed as to the projection, width and thickness of the courses in footings? Alter the foundation of the wall in Figure (*h*), Plate IV and draw the same with footings as necessary, marking the width and thickness of the courses on the sketch.

8. What is a damp course? What are the materials used, and how are they laid? Show the position of a damp course in the wall in Figure (*h*), Plate IV.

9. How are copings formed, and of what materials? Sketch the different sorts of copings as used on brick walls.

10. Name and sketch the different forms of arches used in masonry. Discuss the merits and demerits of each kind, and mention the case in which each is particularly useful. How would you fix the rise and thickness of an arch, and on what do they depend?

11. What are retaining walls, breast walls, revetments walls, and counterforts, and where are they used? Give sketches to make your answer more clear.

12. Figure (*i*), Plate IV is the plan of a part of a first-floor room in a dwelling-house, the boards being carried on common joists $10'' \times 2\frac{1}{2}''$ trimming joists and trimmers $10'' \times 3''$. Give a vertical section through A-A, showing a brick trimmer arch and a lath and plaster ceiling.

13. The roofing of the house in Figure (*h*), Plate IV is supported on wooden king-post roof truss of 20′ span in the clear. Draw the elevation of the truss only to the following dimensions:—Principal rafters $5'' \times 4''$, tie-beam $9\frac{1}{2}'' \times 5''$, struts $3\frac{1}{2}'' \times 2\frac{1}{2}''$, king-post $5'' \times 3''$, ridge board $8'' \times 1\frac{1}{2}''$; purlins, $8'' \times 5''$; pole plates $8'' \times 5''$, common rafters, $4'' \times 2''$, gutter plate $4'' \times 2''$, gutter bearer, $3'' \times 2''$; slate boards $\frac{3}{4}''$ thick, eaves to project $18''$ beyond wall; wall plates $4\frac{1}{2}'' \times 3''$, rise of roof $\frac{1}{4}$ span.

14. Draw the sectional elevation of the roof in Figure (*h*), Plate IV adding countess slates $20'' \times 10''$, lap $3''$, the nail holes on the slate being at a distance from the bottom of the slates equal to the gauge + the lap + half an inch. Show also the stone cornice and blocking course with the lead gutter and flashing.

15. Draw the skeleton diagram with the details of the joints of the iron roof truss that may be substituted for the wooden one of the house in Figure (*h*), Plate IV.

16. Describe fully what you know of well-foundation for bridge-piers.

17. Name the successive operations and the drawings and estimates required for a complete road project, and describe briefly how the road is lined out and constructed.

[1st year will answer 1, 2, 3, 4, 5, 6, 7, 8, and 9; and 2nd year—1, 2, 3, 6, 7, 8, 12, 13, and 15; 3rd year—1, 2, 7, 10, 11, 14 15, 16, and 17.]

DRAWING.

1st, 2nd, and 3rd years.

1. Construct an equilateral triangle equal in area to a square of $1\frac{1}{8}$ inch side.

2. If a side of the square in question 1 represents a length of $37\frac{1}{2}$ feet, draw the scale showing yards and diagonally spaces of 6 inches; and find from the scale the length of the altitude of the triangle in 1.

3. A map is 36 inches long and 30 inches broad: it represents an area of 25 acres; draw the scale of the map to show poles, yards and diagonally feet 4,840 square yards = 1 acre.

4. Construct an elliptic figure, major axis $3\frac{1}{2}$ inches, minor axis $2\frac{1}{2}$ inches, by means of arcs of circles, and draw a tangent to the curve at a given point.

5. Draw a circle equal in area to the sum of three circles of 1 inch diameter each and trisect it by concentric circles.

6. The perimeter of a triangle is 5 inches, the vertical angle is 70°, and one of the sides is half the base. Construct the triangle.

7. The plan and sectional elevation of a stationery case with two vertical partitions are shown in Figure (*j*), Plate IV. Draw an elevation on a line parallel to *xy*, making an angle of 40° with *a*, *b* in the plan.

8. The sector in Figure (*k*), Plate IV is the development of the curved surface of a cone and the chord that of a line on its surface; determine the plan and an elevation of the cone when resting with its base on the ground, showing the line on its surface.

NOTE.—First year will answer questions 1, 2, 3, 4, 5, 6.
Second year ,, ,, 1, 2, 3, 4, 5, 6, 7.
Third year ,, ,, 1, 3, 4, 5, 6, 7, 8.

ESTIMATING.

2nd and 3rd years.

Plate V.

APPRENTICE DEPARTMENT.

FINAL EXAMINATION, 1896.

Arithmetic and Algebra.

1. Simplify $\dfrac{5\frac{1}{2} \text{ of } \frac{2}{9} \text{ of } 2\frac{4}{7} - 1 \div (\frac{1}{5} + \frac{1}{2})}{1 - \frac{3}{14}\left\{\frac{1}{2} + \frac{1}{2}\left(\frac{\frac{1}{20}}{\frac{1}{7} \text{ of } 1\frac{1}{20}}\right)\right\}}$

2. Find the value of $\cdot\dot{7}14285\dot{}$ of £12-13-11½ + $\cdot\dot{2}142857\dot{}$ of £9-1-6 + ·5 of £9-10-1¾.

3. A & B enter into partnership. A puts in £2,100, B £1,500. Four months after C enters the firm with £2,700. At the end of the year the profit is 10% on the whole capital. What share of the profit belongs to each?

4. A person sells 3% Consols at $98\frac{5}{8}$ and realises £2,000. He then invests the amount in the $3\frac{3}{4}$% Railway stock at $93\frac{3}{4}$. What is the change in his income?

5. A note for £500 drawn 9th March at 3 months is discounted 11th April @ 8%. What is received for the note?

6. Add together $7\cdot\dot{4}68\dot{3}$, $95\cdot48347$, $4\cdot6489\dot{6}5\dot{}$, $\cdot0004$.

7. Simplify (*a*) $\dfrac{x^4(y-z) + y^4(z-x) + z^4(x-y)}{x^2(y-z) + y^2(z-x) + z^2(x-y)}$

(*b*) $\dfrac{1+\sqrt{3}}{1-\sqrt{3}} + \dfrac{2+\sqrt{3}}{2-\sqrt{3}} - \dfrac{2\sqrt{3}+1}{2+\sqrt{3}}$

8. Solve (*a*) $\dfrac{2x + 8\frac{1}{3}}{9} + \dfrac{x}{3} + \dfrac{x+16}{36} = \dfrac{7x}{12} - \dfrac{2-13x}{17x-32}$

(*b*) $x(y+z) = 2a$, $y(z+x) = b$, $z(x+y) = c$.

9. Find the L. C. M. of $x^5 + ax^4 + a^2x^3 + a^3x^2 + a^4x + a^5$ and $x^5 - ax^4 + a^2x^3 - a^3x^2 + a^4x - a^5$ and the H. C. F. of $11x^4 - 9ax^3 - a^2x^2 - a^4$ and $13x^4 - 10ax^3 - 2a^2x^2 - a^4$.

10. Extract the square root of (*a*) $61 - 28\sqrt{3}$

(*b*) $6a^{\frac{1}{2}}b^{\frac{1}{2}} + 7a^{\frac{1}{3}}b^{\frac{1}{3}} + b - 6a^{\frac{1}{3}}b^{\frac{1}{2}} + a^{\frac{1}{2}}$.

11. A number consisting of two digits is multiplied by 4, and the product is less by 3 than the number formed by inverting the digits; if it be multiplied by 5 the ten's digit in the product is greater by 1, and the unit's digit is less by 2, than the unit's digit in the original number. Find the number.

Geometry and Mensuration.

1. Prove that the straight lines drawn at right angles to the sides of a triangle from the points of bisection of the sides meet at the same point.

2. If a straight line be divided into any two parts, prove that the sum of the squares on the whole line and one of the parts is equal to twice the rectangle contained by the whole line, and that part together with the square on the other part.

3. Prove that in any quadrilateral the squares on the diagonals are together equal to twice the sum of the squares on the straight lines joining the middle points of opposite sides.

4. Prove that the opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles.

5. If from the vertical angle of a triangle a straight line be drawn perpendicular to the base, prove that the rectangle contained by the sides of the triangle is equal to the rectangle contained by the perpendicular and the diameter of the circle described about the triangle.

6. Each side of a rhombus is 32 feet, and each of the larger angles is equal to twice each of the smaller angles. Find the area.

7. An equilateral triangle and a square have the same area. Compare their perimeters.

8. The side of a square is 12 feet; the square is divided into three equal parts by two straight lines parallel to a diagonal. Find the perpendicular distance between the parallel straight lines.

9. Every edge of a pyramid on a triangular base is 1 foot. Show that the volume of the pyramid is $\frac{\sqrt{2}}{12}$ of a cubic foot, and that the volume of any pyramid on a triangular base which has all its edges equal may be obtained by multiplying the cube of an edge by $\frac{\sqrt{2}}{12}$.

10. The ends of the frustum of a pyramid are equilateral triangles, the lengths of the sides being 6 feet and 7 feet respectively, and the length of a slant edge of the frustum is 9 feet. Find the volume.

Trigonometry and Hydrostatics.

1. Find the values of the sines of the angles 45°, 60°, 120°. Express your answers in decimals.

2. Prove that (1) cos. (A + B) = cos A cos B — sin A sin B.

(2) sin. 3A = 3 sin. A — 4 $\sin^3$ A.

3. Show that in a right angled triangle, in which C is the right angle.

$$(1)\ \sin^2 \frac{B}{2} = \frac{c-a}{2c}$$

$$(2)\ \tan \frac{A-B}{2} \quad \frac{a-b}{a+b}$$

4. Given the sides of a triangle, find its area.

Apply your formula to the case of the triangle whose sides are 7, 9 and 11 inches.

5. A B is a straight length of 500 feet along the bank of a river and C an object on the opposite side. The angle BAC is 33°25′ and ABC 47° 36′. What is the breadth of the river?

6. Given (1) L sin. 37° 17′=9·7822984 and L sin. 37°·18′= 9 7824643, find L sin. 37° 17′ 47″.

(2) L cos. 48° 6′=9·8246676 and L cos. 48° 7′=9·8245267, find L cos. 48° 6′ 34″.

7. Show that the surface of a heavy liquid at rest is horizontal. If the liquid covers a large extent of surface, is this statement correct?

8. Find the direction and magnitude of the resultant pressure on a body immersed in a liquid. Five cubic inches of iron, of specific gravity 7·8, and 3 cubic inches of cork, of specific gravity ·24 are fastened together and completely immersed in water at the ends of a string. Find the tension of the string.

9. State Boyle's Law.

An air bubble at the bottom of a pond 10 feet deep has a volume of 1 cubic inch. What will be its volume at the surface, the barometer standing at 30 inches?

10. Describe the action of a syphon.

The lower end of a syphon at first discharges freely into air. It is then sunk one foot in water. What effect will this have on the discharge?

Statics and Dynamics.

1. What is change of velocity? A point revolves in a circle with unit speed. Find the change of velocity during an interval in which an arc of 30° is described.

2. Prove the formulæ $v=V+at$, $S=Vt+\frac{1}{2}at^2$, $v^2=V^2+2as$. The speed of a train is reduced from 40 miles to 10 miles an hour, whilst it travels a distance of 150 yards; if the retardation be uniform, find how much further it will travel before coming to rest.

3. Show that if a mass m move in a circle of radius r with velocity v, under the influence of a force f tending to the centre of the circle, then $f=m\frac{v^2}{r}$.

4. Find the horizontal pressure on the rails when a 30-ton engine runs at 40 miles an hour on a curve of a mile radius.

5. Find the resultant of two like parallel forces. A straight uniform rod is 3 feet long; when a load of 5 lbs. is placed at one end it balances about a point 3 inches from that end; find the weight of the rod.

6. A uniform rod can turn freely about one of its ends, and is pulled aside from the vertical by a horizontal force acting at the other end of the rod, and equal to half its weight; at what inclination to the vertical will the rod rest?

7. Define stable, unstable, neutral equilibrium. Define the moment of a force about a point. Show that a couple cannot be balanced by a single force.

8. Find the conditions of equilibrium on the inclined plane when the power acts horizontally.

9. Draw a diagram of a system of pullies in which (1) W=63P. (2) W=11P.

ENGINEERING AND APPLIED MECHANICS.

1. Write a specification for 1st class brickwork with lime and surkhi mortar as regards—

(*a*) The materials to be used.
(*b*) The procedure to be adopted in laying.

2. What are the points to be observed in selecting timber for use in engineering construction?

3. What are the more important iron ores?
How is pig iron reduced from an oxide ore?

4. How would you construct a pier of a bridge in a river 6 feet deep, whose bed consists of a firm clay? Give any necessary sketches to illustrate your answer.

5. If a test piece of timber 1 inch square in section and supported on bearings 1 foot apart is just broken by a load of 700 lbs. applied at the middle, determine the side of scantling necessary for the beams of a terrace floor 20 feet span to carry a uniformly distributed load of $1\frac{1}{2}$ cwts. per square foot, the beams being 3 feet apart centre to centre.

6. A reservoir wall 10 feet in height supports 8 feet of water. The dimensions of wall are—

thickness at top $2\frac{1}{2}$ feet.
face batter 1 in 10
back batter 1 in 5 (water presses against this).

Investigate the conditions of stability of the wall, weight of water = 62·5 lbs. per cubic foot, weight of masonry = 125 lbs.

7. Describe any method you know of making an artificial cement, and state what tests you would apply to know whether the cement is fit for use in work or not.

8. A girder of 50 feet span carries a moving load of 1 ton per foot; find the maximum shearing force and bending moment at 10, 20, and 25 feet from one end.

9. What load will a wooden pillar 10 feet long and 5 inches square in section bear, if it be fixed at both ends? The safe co-efficient for compression is 1,200 lbs. and C in Gordon's formula is $\frac{1}{250}$.

Eight questions only to be attempted.

Surveying.

1. Given the angle of intersection of the tangents to a curve at starting and closing points, and the tangent lengths, show how to lay out the curve by offsets from the tangents.

2. The following portion of a level book represents a complete circuit. Fill up the columns for rise, fall, and reduced level, and check the work :—

Number of station.	Back.	Int.	Fore.	Rise.	Fall.	Reduced levels.	Remarks.
B. M.	3·43	...	...	...	...	28·64	B. M. No. 1
1	5·33	...	4·67	...	...	...	...
2	8·66	...	3·75	...	...	...	...
...	...	9·44	...	...	...	...	...
B. M.	...	...	8·27	...	...	...	B. M. No. 1.
...	...	...	...	...	...	...	...

3. If the error in the above circuit occurred in reading the back staff on station 2, show the corrections that would have to be made in the column of reduced levels.

4. Draw full size a portion of a level staff from 2·80 to 3·00, and mark on it a height representing 2·96 feet.

5. Construct a diagonal scale of $\frac{1}{10,000}$th to read to 10 feet.

6. The interior angles of the $\triangle$ A B C are to be observed by a theodolite which is erected to begin with at A. The theodolite at this station is so arranged that when the cross wires intersects the flag at B the reading is zero. When the upper plate is unclamped, and the telescope directed to C, would the observed reading record the interior angle B A C or not? Give reasons for your answer.

7. Draw a scale whose R. F. = $\frac{1}{12}$th and attach a vernier to it to read to inches.

8. Construct a scale of 264 feet to an inch, and draw a square which represents four acres on this scale.

9. In the compass attached to a level, at what graduation on the arc is the north point of the magnetic needle usually fixed? What is the reason of this?

Mechanism and the Steam Engine.

1. Give a sketch of a theoretically perfect indicator diagram, and hence explain what defects are revealed by means of these diagrams.

2. How is the horse power of an engine determined? Distinguish between Nominal, Indicated and Brake Horse Power.

3. Demonstrate the necessity for the use of a fly wheel in a single-acting steam engine. If it is moving too rapidly, sketch and explain any method you know of controlling it.

4. A bicyclist, weighing 140 lbs., is riding a machine weighing 40 lbs. at the rate of 20 miles an hour, if the road offers a resistance of 1 per cent. of their combined weights, what horse power is he exerting?

5. Neglecting friction, what weight may be lifted by two men, each exerting a force of 40 lbs. on the handle of a crab winch of the following dimensions—

length of handle $1\frac{1}{2}$ feet;
pinion attached to handle has 12 teeth;
diameter of drum 1 foot;
spur wheel attached to drum has 72 teeth;
pitch of teeth = $1\frac{1}{2}$ inches.

6. Sketch the winch described in the last question.

7. What is a cam? How would you construct one to give a uniform backward and forward motion?

8. What are the laws that govern the construction of a set of change wheels for use with an ordinary screw-cutting lathe?

Give skeleton sketches of—

(*a*) a force pump,
(*b*) a common suction pump,
(*c*) a steam pressure guage.

Drawing.

1. Draw lines from a point A at every 10° from 0° to 360° Make the line at 0° two inches and the line at 360° one inch in length. Mark off lengths on each of the other lines proportional to the angular distance of each line from 0° and 360°. Find the required lengths by construction only.

2. In a rectangle $3'' \times 2,''$ place an ellipse and mark plainly its major and minor axes and its foci.

3. On a scale of $\frac{1}{1,200}$, represent a cylindrical column 150′ in height and 50′ in diameter by plan and elevation. Find, by construction, the area of thin sheet lead required to cover the curved surface.

4. Construct a diagonal scale to measure accurately to 5 linear feet on a plan where one square inch represents 10,000 square feet.

5. A right-angled $a\overline{\frac{T}{b}}a$ joint is made with cylindrical tubes of thin sheet zinc 2″ in diameter. Draw the development of each of the arms (*a a*) and (*b*), ($\frac{1}{2}$ scale).

6. Give drawings of a dovetail joint between two $4'' \times 3''$ beams at right angles.

Chemistry.

Equations must be given wherever possible.

1. What are the chemical differences between quicklime, slaked lime, and whiting or chalk? By what simple test can whiting be distinguished from lime?

2. Give the composition and two definite and distinctive properties of (*a*) cast-iron, (*b*) steel, (*c*) galvanized sheets, (*d*) tinned-iron sheets, (*e*) brass, and (*f*) soft solder.

3. What is the chemical action which takes place during the burning of coal on a forge-hearth? What volume of air measured in litres at 0°C and 76 cm. pressure, containing 21 per cent. of oxygen by volume, is required to completely burn two kilograms of pure charcoal?

4. Find the percentage composition of ferric oxide.

5. Give a short account of the commercial production of cast-iron.

6. How would you prepare nitric acid and how would you obtain from it nitric oxide?

7. How would you make hydrogen chloride gas? How would you prove that the gas you obtained consisted of hydrogen and chlorine?

8. Acetylene gas is represented by the formula $C_2 H_2$. Give in your own words an exact account of all that is meant by this formula.

Physics.

1. What is the meaning of the statement—the heat of combustion of a certain kind of coal is 6,850, the centigrade degree being the unit difference of temperature; by what number is the calorific power of that same sample of coal expressed, if temperatures are measured by the Fahrenheit thermometers?

2. How much water can be theoretically evaporated from and at 100°C by the heat given out by one ton of the coal referred to in question 1? Show that the water evaporated in a boiler would actually be considerably less.

3. The temperature of the hot well is maintained at 45°C, the temperature of the condensing water is 25°C; the steam enters at a temperature of 55°C. Find the amount of water for condensing 1 lb. of steam under the given conditions. Latent heat of steam at 55°C about 568.

4. Describe Joule's experiment on the conversion of work into heat by the friction between water and a system of vanes.

5. Describe an experiment which illustrates electrostatic induction.

6. By what methods can a steel rod be magnetised?

7. How would you construct a Daniell's cell? Explain its action.

8. What do you know about the telephone?

Estimating.

Plate VI.

MISCELLANEOUS CERTIFICATE HOLDERS.

NAMES.			DATE.
Gopal Chunder Coondoo	...	...	Not traceable.
Gopal Chundra Mookerjee	...	...	
Haran Chundra Bose	...	...	
Judoo Nath Seal	...	...	
Khettra Mohan Bose	...	...	
Khettra Nath Bhuttacharjee	...	...	
Mohendro Nath Bose	...	...	
Mohes Chundra Bose	...	...	
P. Neuville	...	...	
Radhica Narain Ghose	...	...	
Surruth Chundra Ghose	...	...	
Tincowrie Ghose	...	...	
Dino Nath Sen	...	...	
Mothura Nath Chatterjee	...	...	
Jadub Chundra De	...	...	
H. Adams	...	...	
Womes Chundra Ghose	...	...	
Baikantha Nath De	...	...	
E. Gibbert	...	...	1862.
Shib Chunder Mullik	...	...	,,
Madhub Chundra Roy, B.A.	...	...	,,
Ramruttan Mozomdar, B.A.	...	...	,,
Bholanath Das	...	...	,,
Dhones Chundra Roy	...	...	,,
Ram Kissen Mookerjee	...	...	,,
J. D. Beglar	...	...	1863.
Radhica Prosad Mukerjee	...	...	,,
Kally Kumar Coondoo	...	...	,,
Keshub Lal Bose	...	...	,,
J. Robinson	...	...	,,
A. Adams	...	...	,,
Bama Charan Pramanik	...	...	,,
J. O'Flaherty	...	...	,,
W. A. Smith	...	...	,,
A T. Atkinson	...	...	,,
E. James	...	...	,,
A. Dubus	...	...	1864.
Kadar Nath Das	...	...	,,
Ashutosh Mittra	...	...	,,
Poorno Chandra Sarkar	...	...	,,

ASSISTANT ENGINEERS.

NAME.	Year.	REMARKS.
1	2	3
M. King ...	1865	Superintending Engineer, Burmah.
H. P. Crane ...	1865	Retired.
N. A. Richard Chambers ...	1866	
C. Twidale ...	1866	

ASSISTANT ENGINEERS—*concld.*

	NAME.	Year.	REMARKS.
	1	2	3
5	Jay Gopal Rakhit ...	1866	
	Bhola Nath Banerji ...	1866	
	Mohatap Chunder Mullick ...	1867	Surveyor and Assessor, Calcutta Municipality.
	Raj Chandra Ghose ...	1868	Supervisor, Public Works Department.
	Gopal Chandra Bose ...	1868	Sub-Engineer, Jessore Division Public Works Department.
10	C. J. Middleton ...	1870	Deceased.
	J. H. Toogood ...	1871	Executive Engineer, Public Works Department, Bengal.
	F. Murray ...	1871	Executive Engineer, Public Works Department.
	S. H. Jewett ...	1871	Executive Engineer, Assam, and Manager, C. C. S. Railway, Chittagong.
	J. M. Harman ...	1871	Executive Engineer, North-Western Railway.
15	G. J. Joseph ...	1871	District Engineer, Barcili.
	John George Pew ...	1871	Retired.
	Bhuggobutty Charan Gangooly ...	1876	Supervisor, Public Works Department, Bengal.
	Jogendra Chandra Aich ...	1877	Calcutta Municipality.
	Nando Gopal Banerji ...	1878	District Engineer, Purulia.
20	Mohendro Nath Bagchi ...	1879	District Engineer, Howrah.
	Lalit Mohun Basack ...	1881	Also passed L.C.E.
	T. B. Byers ...	1881	Ditto.
	P. W. Byers ...	1881	Ditto.
	Kapileswar Bhattacharjee ...	1881	
25	Sita Prosono Rai ...	1882	Supervisor, Public Works Department, Bengal.
	Mritunjoy Bhattacharjee ...	1882	Engineer to Maharani Surnomoye.

List of Students who have passed the theoretical part of the examination for the License in Civil Engineering.

H. M. Adams ...	1861	
Mothura Nath Chatterjee ...	1861	
Baikanthanath De ...	1861	
Jadub Chandra De ...	1861	
Umesh Chundra Ghosh ...	1862	
Diha Nath Sen ...	1862	
Mohendra Lal Chandra ...	1862	
Hem Chandra Chatterjee ...	1862	
Kunjabihari Chowdry ...	1862	
Bholanath Das ...	1862	
Motilal De ...	1862	
Ramesh Chandra Ghosh ...	1862	
Parbutty Charan Mittra ...	1862	
Benode Chandra Mukerjee ...	1862	
Ram Krishna Mukerjee ...	1862	
Pundit Surya Kumar ...	1862	
Dhaneschandra Roy ...	1862	

SUB-ENGINEERS.

	NAME.	Year.	REMARKS.
	1	2	3
	C. Twidale ...	1865	
	T. Patterson ...	1866	
	Gopal Chandra Daw ...	1866	Sub-Engineer, Public Works Department, Bengal.
	J. D. Douglas ...	1866	
5	J. Joseph ...	1866	
	J. Atkinson ...	1866	
	Nolin Behary Ghose ..	1869	
	Hem Kantta Deb ..	1869	Supervisor, Public Works Department, Bengal.
	Raj Kumar Mookerji ...	... ..	
10	Kedar Nath Roy ...	1870	Supervisor, Public Works Department, Bengal.
	Grish Chundra Das ...	1870	
	Budhoo Sukhar Banerji ...	1870	
	Koororam Ray ...	1870	Survey Teacher, Bankipore.
	Gopal Chandra Ghosh ...	1871	Sub-Engineer, Public Works Department, Bengal.
15	Preo Nath Ghose ...	1871	
	Chandra Bhusan Dutt ...	1871	Ditto ditto.
	Hem Chandra Mitter ...	1871	
	Tarincy Charan Sircar ...	1871	Sub-Engineer, Public Works Department, Bengal.
	Trailokho Nath Sircar ...	1871	Supervisor, Public Works Department.
20	Charu Chandra Bose ...	1872	
	Thackoordas Ghosh ...	1873	
	Akshoy Krishna Bose ...	1874	Supervisor, Public Works Department, Bengal.
	Radha Nath Sen ...	1874	
	Soorendro Nath Gupta ...	1874	
25	Sasi Bhusan Mitra ...	1874	District Engineer, Dacca.
	Giris Chandra Bhor ...	1874	
	Kenaram Bose ...	1874	
	Chandra Seekhar Das ...	1874	Sub-Engineer, Midnapore District Board.
	Kisori Mohan Mookerji ...	1875	District Engineer, Balasore.
30	Haran Chandra Chatterji ...	1875	
	Chander Coomar Chatterji ...	1875	
	Rajendro Nath Neogy ...	1875	
	Priya Nath Mookerji ...	1875	
	Rajendro Lal Sarkar ...	1876	
35	Mohini Mohan Bagchi ...	1876	
	Uma Charan Banerji ...	1876	
	Balai Chand Rana ...	1876	Calcutta Municipality.
	Amerto Lal Roy ...	1876	
	Sures Chunder Gangooly ...	1876	Supervisor, Public Works Department.
40	Atul Krishna Mookerji ...	1876	
	Behari Lal Das ...	1876	
	Purna Chandra Chatterji ...	1876	Sub-Engineer, Public Works Department.
	Kedar Nath Gangooly ...	1876	

SUB-ENGINEERS—*concld.*

	NAME.	Year.	REMARKS.
	1	2	3
	Mohendro Nath Bagchi ...	1877	District Engineer, Howrah.
45	Mohendro Nath Bhattacharjee ...	1877	
	Ram Lal Bhar ...	1877	
	Radharomone Guho ...	1877	Teacher, Survey School, Dacca.
	Abhay Charan Datt ...	1878	Calcutta Municipality.
	Fakir Chand Mookerjee ...	1878	Overseer, District Board, Darbhanga.
50	Sasi Bhusan Bhattacharjee ...	1878	
	Brojo Lal Sett ...	1878	
	Charles William Merton ...	1879	Sub-Engineer.
	Ram Das Bhattacharjee ...	1884	Public Works Department, Bengal.
	V. S. Viney* ...	1896	
55	Bhubonesh Chuckerbutty* ...	1896	
	Apurbo Dhone Ray* ...	1896	

* Also holds Foreman Mechanics and Upper Subordinate certificate, *vide* page 153.

Foreman Mechanics and Upper Subordinates.

	Ashini Kumar Mookerjee ...	1883	Public Works Department, Burmah.
	A. E. DeSilva ...	1883	
	W. Traise ...	1883	Public Works Department, Bengal.
	W. M. Halloran ...	1883	Public Works Department, Bengal.
5	F. Alone ...	1883	Overseer, District Board, Benares.
	H. Gilbert ...	1883	Public Works Department, Assam.
	J. R. Moorhouse ...	1883	Foreman, North-Western Railway Workshops, Lahore.
	E. B. Walker ...	1883	Calcutta Municipality.
	H. Bryning ...	1885	Overseer, B. S. Railway, Swebo.
10	C. Periera ...	1885	Calcutta Municipality.
	T. Rolston ...	1885	Public Works Department, Burma.
	Shoshi Bhusan Ghosh ...	1885	District Board, Chapra.
	Shaik Sudder Ali ...	1886	Burma Public Works Department.
	G. Branscombe ...	1886	Overseer, Arracan Division, Burma.
15	Bani Kanta Biswas ...	1886	Faridpur Municipality.
	Sarat Chundra Roy ...	1886	Chittagong Public Works Department.
	Jogesh Chundra Bose ...	1886	Public Works Department, Bengal.
	Nagoni Nath Bál ...	1886	District Board, Mymensingh.
	Basanta Kumar Ghosh ...	1887	Midnapore Technical School.
20	Raghupati Banerjee ...	1887	District Board, Purnea.
	A. Cuerden ...	1887	Overseer, North-Western Provinces.

	Name.	Year.	Remarks.
	1	2	3
	Harilal Sanyel ...	1887	Faridpur District Board.
	O. A. Browne ...	1887	Public Works Department, Berars.
	J. C. Damzen ...	1887	East Indian Railway, Allahabad.
25	W. Gomes ...	1887	Overseer, Public Works Department, Mandalay.
	Tranoda Churn Mittra ...	1887	Calcutta Public Works Department.
	J. H. Roy ...	1887	India General Steam Navigation Company's steam-ship *Lucknow*.
	Upendra Nath Ganguli ...	1887	Deceased.
	Tuniram Borua ...	1887	Assam.
30	Bhuban Chundra Banerjee ...	1888	Employed.
	Nogendra Nath Chakravarti ...	1888	Public Works Department, Bengal, Railways.
	Jodunath Biswas ...	1888	Sub-Overseer, Public Works Department.
	E. Martin ...	1888	Eastern Bengal State Railway, Lungi, Budge-Budge.
	Heralal Pal ...	1888	Surveyor-General's Office, Calcutta.
35	Keshub Lal Chatterjee ...	1888	Kidderpore Dock.
	R. Rogers ...	1888	Foreman, Lahore Workshop.
	C. Hodge ...	1888	Overseer, Midnapore Municipality.
	Batta Krishna Singh ...	1888	Public Works Department, Bengal.
	Harish Chandra Pal ...	1888	Public Works Department, Bengal.
40	Ashutose Bhattacharjee ...	1888	Chittagong Public Works Department.
	A. E. Linton ...	1888	East Indian Railway.
	G. Morris ...	1888	Public Works Department, Cheera Punji.
	A. Bonnar ...	1888	
	Surendronath Mittra ...	1888	Deceased.
45	Sarat Chundra Bose ...	1889	Burn & Co., Howrah.
	P. Westerling ...	1889	Deceased.
	C. Hottinger ...	1889	Overseer, Public Works Department, Toungoo.
	Kartick Chunder Bose ...	1889	Private works, Calcutta.
	H. Michael ...	1889	Mackintosh, Burn & Co.
50	Degumber Hui ...	1889	District Board, Muzaffarpur.
	Rohini Kumar Bhattacharjee ...	1889	Overseer, Public Works Department, Burmah.
	G. M. Gregory ...	1889	Clerk of Works, Balang-Padang, Perak.
	Jogendra Nath Ganguli ...	1890	Survey Teacher, Patna College.
	Nripendra Nath Bose ...	1890	Public Works Department Sub-Overseer, Bengal.
55	Srimanta Ch. Chaudhri ...	1890	
	Brojendra Kumar Dass ...	1890	Overseer, Karremgunge.
	D. W. D'Cruze ...	1890	Way Inspector, S. I. Ry., Trichonopoly.
	C. J. Homer ...	1890	Overseer, Public Works Department, Burmah.

	Name.	Year.	Remarks.
	1	2	3
	G. F. Hottinger ...	1890	Overseer, Public Works Department, Bassin Division.
60	J. S. O'Connell ...	1890	Deceased.
	Sreekanta Roy ...	1890	Overseer, Local Board, Pirojpur, Barisal.
	Romesh Chunder Dutt ...	1890	Sub-Overseer, Public Works Department, Bengal.
	Modhu Sudan Adhicary ...	1890	Sub-Overseer, Public Works Department, Bengal.
	Surjee Kumar Chatterjee ...	1890	
65	Rojoni Kanta Deb ...	1890	Kashipore Municipality Surveyor.
	Upendra Nath Hazra ...	1891	
	Panch Cowri Mukerjee ...	1891	Sub-Overseer, Public Works Department.
	Satis Chundra Mittra ...	1891	
	J. G. Dolmar ...	1891	
70	Gyanendra Nath Banerjee ...	1891	Private Workshop, Sibpur.
	Kristo Dhone Ghose ...	1891	Overseer, Public Works Department, Arrah.
	R. D. Clark ...	1891	
	Haran Chundra Biswas ...	1891	
	Hari Narayan Sarkar ...	1891	
75	Chandra Kanta Chatterjee ...	1891	
	A. H. Smellie ...	1891	
	Mothura Nath Lahiri ...	1892	
	Protap Chander Ghose ...	1892	Public Works Department, Bengal.
	Sidheswar Shaha ...	1892	Superintendent, Technical School, Rangpur.
80	Upendra Nath Datt ...	1892	
	Dwark Nath Bose ...	1892	Overseer, District Board, Ranchi.
	Gopal Chander Sen ...	1892	Sub-Overseer, Public Works Department, Bengal.
	Fazlal Karim ...	1892	Superintendent, Burdwan Technical School.
	Suresh Chander Banerji ...	1892	Public Works Department, Burma.
85	Benode Behary Roy ...	1892	
	Surjya Coomar Samonta ...	1892	District Board, Dacca.
	Deb Lal Ghosal ...	1892	Survey Teacher, Cuttack.
	Tara Pado Banerji ...	1892	3rd grade Overseer, Burma.
	Bhola Nath De ...	1892	Ditto ditto.
90	J. Morrison ...	1892	Public Works Department, Burma.
	Battu Krishna Mookerjee ...	1893	3rd grade Overseer, Public Works Department, Khurda.
	Sotish Chander Pramanik ...	1893	
	J. Wise ...	1893	
	Norendro Nath Chatterjee ...	1893	Public Works Department, Comilla.
95	Hera Lal Sarkar ...	1893	Head Master, Technical School Purnea.
	Gonesh Chander Chuckerbutty	1893	District Board, Hooghly.
	Bossunto Kumar Roy ...	1893	Match Factory, Calcutta.
	Aswini Kumar Sen ...	1893	3rd grade Overseer, Public Works Department, Madras.

	Name.	Year.	Remarks.
	1	2	3
	Tincouri Biswas ...	1893	Head Master, Technical School Mymensingh.
100	Bhupendro Bhusan Gungooly ...	1893	District Board, Burdwan.
	Sotish Chander Baksi ...	1894	Overseer in the State Railways.
	Bisseswar Mookerji ...	1894	Overseer in the State Railways.
	Sarat Chander Hazrah ...	1894	
	Hera Lal Neogi ...	1894	
105	Surendro Nath Dutt ...	1894	
	Suresh Chander Mozoomdar ...	1894	
	Surendro Nath Bose ...	1894	
	Bepin Behary Sen Gupta ...	1894	
	W. F. Gardiner ...	1895	
110	Mati Lal Paul ...	1895	
	M. C. Petters ...	1895	
	J. Parsons ...	1895	
	Barada Kanta Mazumdar ...	1895	
	Upendra Nath Bosu ...	1895	
115	Nani Lal Sarkar ...	1895	
	Annada Charan Guha ...	1895	
	W. Jordan ...	1895	
	D. Lemon ...	1895	
	Jyotish Chander Chakervarti ...	1895	
120	Kally Krishna Paul ...	1895	
	R. V. Aguilar ...	1895	
	Gopal Prosad Chatterjea ...	1895	
	Durga Pada Bosu ...	1895	
	Sita Nath Ghosh ...	1895	
125	C. Tibbetts ...	1895	
	Barroda Prosad Ghosh ...	1895	
	W. S. Viney* ...	1896	
	Srish Chandra Nandi ...	1896	
	Bhubonesh Chakrabutty* ...	1896	
130	Sydney Ernest Ansell ...	1896	
	Apurba Dhone Roy* ...	1896	
	Ashutosh Bose ...	1896	
	Upendra Nath Bhattacharjee ...	1896	
	A. Wilsen ...	1896	
135	Anath Nath Mukerjee ...	1896	
	D. Showers ...	1896	
	Sarat Chander Dawn ...	1896	
	Abdul Haque ...	1896	
	Peary Lal Bhattacharjee ...	1896	
140	Norendra Chander Aich ...	1896	
	A. J. Chater ...	1896	
	R. Young ...	1896	
	Jagadish Chander Bose ...	1896	
	W. Glynn ...	1896	

* Also holds Sub-Engineers certificate, *vide* page 149.

List of Passed Apprentices who obtained Guaranteed Appointments as 3rd grade Overseers, Railway Branch.

	Names.	Year.	Remarks.
	1	2	3
	Bhola Nath De ...	1892	
	Tara Pado Banerji ...	1892	
	Batu Krishna Mookerjee ...	1893	
	Aswini Kumar Sen ...	1893	
5	Sotish Chander Baksi ...	1894	
	Bisseswar Mookerji ...	1894	
	Mati Lal Pal ...	1895	
	Srish Chunder Nandi ...	1896	

N.B.—Any inaccuracies in above list should be brought to the notice of the Principal. Passed apprentices out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any apprentice getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

Overseers.

	J. Kelly ...	1865
	Boycunt Nath Roy ...	1865
	Chandra Coomar Chatterji ...	1865
	Gopal Chander Daw ...	1865
5	Ashootosh Mitra ...	1865
	Netro Gopal Ray ...	1865
	Khetter Nath Ghosal ...	1865
	H. E. B. Fox ...	1865
	Kartic Chandra Ghose ...	1866
10	Rojoney Cant Mookerji ...	1866
	Laul Gopal Banerji ...	1866
	Kally Prosono Mozoomdar ...	1866
	Kally Das Das ...	1866
	Hem Chandra Banerjee ...	1866
15	Kristo Chandra Gupta ...	1866
	Rakhal Dass Chatterji ...	1866
	Galam Ahmed ...	1866
	Mohendro Nath Mullick ...	1866
	Kaylash Chandra Mookerjee ...	1866
20	Brindaban Chunder Ghose ...	1867
	W. I. Dukes ...	1867
	Sashi Bhusan Chatterji ...	1867
	Gopal Chandra Mookerji ...	1867
	Kassi Kantha Pramanik ...	1867
25	Jadu Nath Bose ...	1868
	Saroda Charan Bose ...	1868
	Shurrat Chandra Sandal ...	1868
	Nolin Behary Ghose ...	1868
	Soshi Bhusan Chatterji ...	1868
30	Nogendra Chandra Mozoomdar	1868
	Roodro Prosono Sing ...	1868
	Hera Lal Mitra ...	1868
	Toolsy Das Roy ...	1869
	Bhoggobutty Gangooly ...	1869

OVERSEERS—*contd.*

	NAME.	YEAR.	REMARKS.
	1	2	3
35	Ram Nath Bhattacharji ...	1869	
	Siddeshur Chatterji ...	1869	
	Opendra Lal Gupta ...	1869	
	Kristo Nath Banerji ...	1869	
	Narain Chandra Naug ...	1869	
40	Sookmoy Mullick ...	1869	
	Edward Browne ...	1869	
	Otool Krishna Mitra ...	1870	
	Mutty Lal Mozumdar ...	1870	
	Sree Churn Roy ...	1870	
45	Srinibas Bose ...	1870	
	Goluck Nath Sen ...	1870	
	Tara Prasonno Mookerji ...	1870	
	George A. Laval ...	1870	
	Koylash Chandra Chowdhury ...	1871	
50	Bhobo Tara Ghose ...	1871	
	Mohendro Nath Sarkar ...	1871	
	Avinas Chandra Mookerji ...	1872	
	Bama Charan Banerji ...	1873	
	Jogendra Lal Chatterji ...	1873	
55	Umesh Chandra Banerji ...	1873	
	Baney Madhub Chatterji ...	1873	
	Aghore Lal Bose ...	1873	
	Sasi Bhusan Mitra ...	1873	
	Bepin Behary Mozoomdar ...	1873	
60	Koylas Chandra Mitra ...	1874	
	Kedar Nath Chowdhury ...	1874	
	Hera Lal Mitra ...	1874	
	Mutty Lal Sen ...	1874	
	Monmotho Nath Chatterji ...	1874	
65	Raj Krishna Mookerji ...	1874	
	Moti Lal Chowdhury ...	1874	
	Gunga Charan Gangooly ...	1875	
	Kartickya Biswas ...	1875	
	Mohendro Lal Das ...	1875	
70	Jet Narain Dutt ...	1875	
	Behari Lal Das ...	1875	
	Krishna Sakha Das ...	1875	
	Aughore Chandra Ghose ...	1875	
	Gossein Das Dutt ...	1875	
75	A. Malcolm ...	1876	
	Sheik Azizar Ruhmon ...	1876	
	Kunjo Behary Bose ...	1876	
	Moti Lal Banerji ...	1876	
	Priya Nath Mitra, No. 1 ...	1876	
80	Jotendra Krishna Basack ...	1876	
	Hem Chandra Mookerji ...	1876	
	Ganandra Prosad Roy ...	1876	
	Chhatradhor Ghose ...	1876	
	Jodu Nath Banerji ...	1876	
85	Kalidhan Bhattacharji ...	1876	
	Godadhur Sen ...	1876	
	Prosonno Coomar Bose ...	1876	

OVERSEERS—*contd.*

	NAME.	Year.	REMARKS.
	1	2	3
	Charles William Merton ...	1876	
	Hari Nath Sen Gupta ...	1876	
90	Monmohun Ghose ...	1877	
	Sasi Bhusan Dutt ...	1877	
	Ram Lal Bhor ...	1877	
	Chuni Lal Sahu ...	1877	
	Lal Behary Roy ...	1877	
95	Ram Das Bhattacharji ...	1877	
	Kedar Nath Mozoomdar ...	1877	Overseer, Darjeeling.
	Avinas Chandra Champati ...	1877	Overseer, District Board, Gaya.
	Gholam Ruhmon ...	1877	
	Preo Nath Mookerji ...	1877	
100	Hem Chandra Nandi ...	1877	
	Brojo Lal Sett ...	1877	
	Nivaran Chandra De ...	1877	
	Hari Das Chatterji ...	1877	
	Madhub Chunder Chuckerbutty	1877	
105	Debendro Nath Mookerji ...	1877	
	Khetra Mohan Mookerji ...	1877	
	Frank Hardy ...	1877	
	N. Cartland ...	1877	
	William Radford ...	1877	
110	Daniel Farren ...	1877	
	H. Williamson ...	1877	
	Jogendro Nath Ghose ...	1877	
	A. W. Gantzer ...	1877	
	Amal Chander Mullick ...	1877	
115	Hari Charan Mookerji ...	1877	
	Troyluckho Dhor ...	1877	Overseer, Public Works Department.
	Hem Chandra Das ...	1877	
	Gyanoda Prosad Ghosal ...	1878	
	Apurvo Chandra Gangooli ...	1878	
120	Priya Nath Mitra ...	1878	
	Hari Das Basack ...	1878	
	Behari Nath Sen ...	1878	
	Upendro Nath Banerji ...	1878	
	Upendro Nath Chuckerbutty ...	1878	
125	Nursing Chandra Mookerji ...	1878	
	Giris Chandra De ...	1878	
	T. B. Byers ...	1879	
	Sri Gopal Bose ...	1879	Sub-Overseer, Sone Circle.
	Atul Chandra Banerji ...	1879	
130	Nobin Chundra Ghose ...	1879	
	Goluck Chander Mookerji ...	1879	
	Jogendro Nath Gangooli ...	1879	
	Hari Charan Bose ...	1879	
	Norendro Nath Banerji ...	1879	
135	Bama Charan Mullick ...	1879	
	Jogendro Nath Chatterji ...	1879	
	Asutosh Ghosh ...	1879	
	Amin Uddin ...	1880	
	Abinas Chunder Roy ...	1880	Also passed L.C.E.
140	Kapileswar Bhattacharjee ...	1880	Passed for Assistant Engineer.

OVERSEERS—*concld.*

	NAME.	Year.	REMARKS.
	1	2	3
	Nemi Churn Ghose ...	1880	
	Gopal Chunder Bhattacharje ...	1880	
	Russick Lal Mukerjee ...	1880	
	Lolit Mohun Basak ...	1880	Passed L.C.E.
145	Pran Krishna Sen ...	1880	Ditto.
	Sita Prosonno Rai ...	1880	Ditto.
	Bishnuram Chakraverti ...	1880	
	Satya Churn Banerjee ...	1881	Ditto.
	Kali Krishna Mozoomdar ...	1881	
150	Apurva Krishna Sen ...	1881	
	Kali Gopal Rudra ...	1881	
	C. E. Lefeuvre ...	1882	
	Annoda Prosad Pal ...	1882	
	Shama Churn Ganguli ...	1882	
155	Akhil Chunder Marik ...	1883	Ditto.
	Lal Chand Mittra ...	1883	
	Banku Behari Mukerjee ...	...	Ditto.

Certificates granted under Director of Public Instruction's No. 5, dated 23rd July 1894.

THIRD GRADE OVERSEERS.

	Kuloda Nanda Mukerjee ...	1885	
	Preo Nath Roy ...	1886	
	Jadu Nath Mittra ...	1886	
	Surendra Nath Sen ...	1886	
5	Troylocko Nath Dutt ...	1888	
	Gopal Chundra Roy ...	1888	
	Nebaran Chundra Chatterjee ...	1888	
	Surja Kumar Das ...	1889	
	Makhan Lal Sarkar ...	1890	
10	Chanchal Chundra Banerjee ...	1890	
	Jogendra Lal Pal ...	1890	
	Notobar Ghosal ...	1891	
	Kaliprosonno Sen ...	1891	
	J. Morrison ...	1891	
15	Mohindro Chandra Paul ...	1892	
	Gopeswar Roy ...	1892	
	Gobindo Chandra Boral ...	1892	
	Hari Mohan Mukerjee ...	1896	
	Sachipati Das ...	1896	
20	Jogendra Nath Choudhuri ...	1896	

SUB-OVERSEERS.

	NAME.	Year.	REMARKS.
	1	2	3
	Saroda Charan Bose ...	1865	
	Mohendro Nath Bhattacharji ...	1866	
	Kally Kristo Dutt ...	1866	
	Nilmoni Banerji ...	1866	
5	Boggobutty Charan Gangooly ...	1868	
	Saroda Prosad Chatterji ...	1869	
	Audhor Chandra Roy Chowdhury	1870	
	Seddeshur Mitra ...	1870	
	Kashishur Mukerji ...	1870	
10	Chandra Kanthi Mukerji ...	1870	
	Khetra Mohun Palit ...	1870	
	Tarrack Nath Gangooly ...	1870	
	Shib Chander Banerji ...	1870	
	Bama Charan Roy ...	1870	
15	Eshan Chandra Singh ...	1871	
	Mohendro Chandra Palit ...	1871	
	Raj Krisen Ghose ...	1871	
	Bama Charan Banerji ...	1871	
	Kali Kristo Roy ...	1871	
20	Kali Prosonno Mookerji ...	1871	
	Akhoy Kumar Roy ...	1872	
	Khetra Mohun Mitra ...	1872	
	Akhoy Kumar Chowdhry ...	1872	
	Sosi Bhusan Dutt ...	1873	
25	Kedar Nath Chowdhry ...	1873	
	Surja Kantha Banerji ...	1874	
	Ram Doyal Roy ...	1874	
	Hari Lal De Chowdhury ...	1874	
	Jogendro Nath Mookerji ...	1874	
30	Gris Chandra Banerji ...	1874	
	Debendra Nath Roy Chowdhry	1874	
	Rajendra Nath Biswas ...	1874	
	Hem Chundra Sarkar ...	1874	
	Chandy Charan Satrah ...	1874	
35	Bedhu Bhusan Trevady ...	1874	
	Brindaban Chandra Mondul ...	1874	
	Annodo Charan Brahmo ...	1874	
	Nil Kantta Dutt ...	1874	
	Umes Chandra Sen ...	1874	
40	Sita Nath Ghose ...	1874	
	Ahin Chandra Mookerji ...	1875	
	Saroda Prosad Samonto ...	1875	
	Isan Chandra Chowdhry ...	1875	
	Puno Chunder Daw ...	1875	
45	Abinas Chandra Mullick ...	1875	
	Prosono Kumar Bose ...	1875	
	Gooroo Prosono Banerji ...	1875	
	Kunjo Behari Bose ...	1875	
	Romun Kristo Ghosh ...	1875	
50	Brojo Pati Banerji ...	1875	
	Modan Mohan Bysack ...	1875	
	Ram Chandra Bysack ...	1875	
	Moti Lal Banerji ...	1875	

SUB-OVERSEERS—*concld.*

NAME.	Year.	REMARKS.
1	2	3
Bhamudra Kumar Ghose	1875	
55 Isvar Chandra Das	1875	
Akhil Chandra Sen	1875	
Jogendra Nath Ghose	1875	
Joy Krishna Chatterji	1875	
Asvini Kumar Bose	1875	
60 Avinas Chandra Roy	1876	
Ram Narain Pal	1876	
Sri Kanto Sinha	1876	
Ram Doyal Pal	1876	
Dharmodas Laha	1876	
65 Chuni Lal Saha	1876	
Narain Chander Chatterji	1876	
Lal Behary Ray	1876	
Chandi Charan Hazra	1877	
Govindo Chunder Roy	1877	
70 Umes Chunder Sen	1877	
Gopal Chander Bhattacharji	1877	
Syma Prosad Rai	1877	
Jogendro Kumar Bose	1877	
Hera Lal Mookerji	1877	
75 Deno Nath Gui	1877	
Avinas Chandra Bose	1877	
Amieruddin	1878	
Chuni Lal Mitra	1878	
Kedar Nath Nag	1878	
80 John James FitzWilliam	1878	
Chandra Kantha Basack	1878	
Upendra Nath Kanjilal	1878	
W. Bowers	1878	
Guru Doyal Kundu	1878	
85 Kali Charan Mookerji	1878	
Bepin Behary Bose	1879	
Bama Charan Mookerji	1879	
Romesh Chandra Sen	1879	
Kaisiki Charan Gupta	1879	
90 Atul Chandra Mookerji	1879	
Bani Madhub Mullick	1879	
Avinas Chandra Roy	1879	
Asutosh Chatterji	1879	
Sudhamay Dutt	1880	
95 Monmotho Nath Mukerjee	1880	
Haripodo Chatterjee	1880	
Sivadas Bhattacharjee	1881	
Lal Chand Mittra	1881	Also passed as Overseer.
Sarat Chunder Roy	...	
100 Annoda Prosad Sarkar	1881	Passed L.C.E.
Tarini Churn Roy	1881	
Mohim Chunder Rudra	1882	
Banwari Lal Banerjee	1883	
Chandra Kanta Bose	1890	

Certificates granted under Director of Public Instruction's No. 4231, dated 15th May 1894.

SUB-OVERSEERS.

	NAME.	Year.	REMARKS.
	1	2	3
	Raj Kumar Ganguli ...	1884	
	Jadub Chunder Chatterjee ...	1885	
	Bepin Behari Gupta ...	1885	
	Sitanath Bhuttacharjee ...	1885	
5	Nikunja Behari Bose ...	1886	
	Bejoy Krishna Mukerjee ...	1886	
	Nritya Gopal Bhuttacharjee ...	1886	
	Raj Krishna Mandal ...	1887	
	Heera Lal Santra ...	1887	
10	Chanchal Chundra Banerjee ...	1887	Also passed as 3rd grade Overseer.
	Kaliprosonno Sen ...	1887	Ditto ditto.
	Baroda Kanta Thakoor ...	1888	
	Sidheswar Mozoomdar ...	1888	
	Gopal Chundra Lahiri ...	1888	
15	Upenda Nath Sen Gupta ...	1888	
	Mohendra Nath Gossamy ...	1888	
	Kamini Kanta Bhuttacharjee ...	1888	
	Upendra Nath Chandra ...	1888	
	Annoda Churn Ghose ...	1888	
20	Protap Chunder Ghose ...	1889	
	Dakshinaranjan Muchaddi ...	1889	
	Tarak Nath Chowdhry ...	1891	
	Soshibhusan Bhuttacharjee ...	1891	
	Pulin Behari Ghose ...	1891	
25	Brindaban Chundra Mukerjee ...	1891	
	Pulin Behary Shaha ...	1891	
	Jaggut Bundhoo Gupta ...	1891	
	Brojendra Nath Chatterjee ...	1891	
	Saroda Prosad De ...	1891	
30	Surendra Nath Banerjee ...	1891	
	Ashutosh Chatterjee ...	1891	
	Nogendranath Chatterjee ...	1891	
	Lalbehary Roy ...	1891	
	Debendra Nath Sen Gupta ...	1891	
35	Jogendra Nath Ghose ...	1891	
	Surjya Kumar Roy ...	1891	
	C. Raynard ...	1891	
	Panchanun Ganguli ...	1891	
	Purna Chandra Dutt ...	1891	
40	Dakshineswar Chatterjee ...	1891	
	Sarat Chandra Das ...	1892	
	Jogendro Nath Mookerji ...	1892	
	Ashutosh Bhattacharjee ...	1892	
	Punna Lal Banerji ...	1892	
45	Nekunjo Behari Gupta ...	1892	
	Nobo Kumar Shaha ...	1892	
	Bidhu Bhusan Sen ...	1892	
	Sasi Bhusan Nag ...	1892	
	Behari Lal Ghose ...	1892	
	Debendro Nath Bhattacharj No. 2	1892	
	Rungo Lal Mookerji ...	1892	

SUB-OVERSEERS—*contd.*

NAME.	Year.	REMARKS.
1	2	3
Debendro Nath Bhattacharji ...	1892	
Gokul Chandra Roy ...	1892	
Keshub Lal Gangooly ...	1892	
55 Girindro Chandra Ghose ...	1892	
Durga Pado Bose ...	1892	
Akshoy Kumar De ...	1892	
Russick Lal Dutt ...	1892	
Peari Mohun Mookerji ...	1892	
60 Neebaran Chandra Das ...	1892	
Jotindro Krishna Bose ...	1892	
Bepin Bihary Banerjee ...	1893	
Vishnu Pado Ghosal ...	1893	
Ananda Ram Das ...	1893	
65 Umesh Chandra De ...	1893	
Bepin Behary Bose ...	1893	
Bhudeb Kundu ...	1893	
Sosodhor Mondol ...	1893	
Satyendro Nath Chatterjee ..	1893	
70 Kamini Kumar Kar ...	1893	
Mohim Chander Das ...	1893	
Radhika Mohun Das ...	1893	
Ananto Lal Bose ...	1893	
Sasty Das Chatterjee ..	1893	
75 Debendro Nath Chatterjee ...	1893	
Sarat Chander Barooah ...	1893	
Banku Behary Mytie ...	1893	Public Works Department, Bengal.
Benode Behary Nandi ...	1893	
Syama Charan Mitra ...	1893	
80 Kunjo Mohan Biswas ..	1894	
Benode Behary Sanyal ...	1894	
Goury Sunkar Mookerji ...	1894	
Anukul Chander Lahiri ...	1894	
Surendro Nath Chatterji ...	1894	
85 Sushil Kumar Mookerji ...	1894	
Satish Chander Chukerbutty ...	1894	
Surendro Nath Chowdhury ...	1894	
Nirmul Chander Banerji ...	1894	
Bassanto Kumar Ray ...	1894	
90 Sarat Chander Sarkar ...	1894	
G. Dukes ...	1894	
Hari Pada Chatterjea ...	1895	
Purusattam Das ...	1895	
Durga Das Samanta ...	1895	
95 Hari Charan Das ...	1895	
Jogesh Chander Bhuttacharjee	1895	
F. Goodwin ...	1895	
Rajani Bhusan Roy ...	1895	
Kedar Nath Mannah ...	1895	
100 Hari Satya Bosu ...	1895	
Panchrnan Jash ...	1895	
Gopal Das Mukherjee ...	1895	
Jotinera Nath Dutt ...	1895	
Sita Nath Hoar ...	1895	
105 Surendra Nath Ghosh ...	1895	

SUB-OVERSEERS—*concld.*

	NAMES.	YEAR.	REMARKS.
	1	2	3
	Fatik Chandra Ghose ...	1896	
	Narayan Das Mookerjee ...	1896	
	Akhoy Kumar Mookerjee ...	1896	
	Sailendro Nath Chatterjee ...	1896	
110	Atul Chandra Deb ...	1896	
	Probodh Chander Mitra ...	1896	
	Probodh Chander Sanyel ...	1896	
	J. R. Rodgers	1896	
	Jotendro Nath Roy Chowdhoory	1896	
115	Upendro Nath Bhattacharjee ...	1896	
	Apurbo Krishna De ...	1896	
	Hari Das Chatterjee ...	1896	
	Nibarun Chandra Bose ...	1896	
	Kishori Mohan Bhattacharjee ...	1896	
120	Akshoy Kumar Dutt ...	1896	
	Gokul Chandra Chatterjee ...	1896	
	Basanta Kumar Chatterjee ...	1896	

Artizans.

	Hem Chandra Dutt ...	1889	
	Bhakunda Dutt ...	1889	
	Deo Ram Dutt ...	1890	
	Roop Ram Dutt ...	1890	
5	Bondo Lal Gogai ...	1892	
	Purna Chander Gogai ...	1892	
	Asoph Tega ...	1895	
	Sodanand Subarno ...	1895	
	Subman Tega ...	1895	
10	Johan Churka ...	1896	
	Amoas Terkey ...	1896	
	Mattoon Mankal ...	1896	

ACCOUNTS.

Examination qualifying for admission to the Subordinate Accounts Branch for 4th Grade, P. W. D.

Subjects.		Full marks.	Minimum pass marks
Writing (neatness, clearness, and rapidity)	...	100	50
Dictation (spelling, punctuation, etc.)	...	100	50
Arithmetic (the whole) ,, ...	...	240	160
Mensuration (*a*) the whole ...	...	60	30
Book-keeping (*b*) mercantile ...	...	100	50
Total	...	600	400

Minimum required in all papers collectively.

(*a*) Todhunter's Mensuration for Beginners.
(*b*) "Book-keeping" by Bull and Hamilton.
"Book-keeping" by double and single entry, by W. Inglis (Chambers' Educational Course).

The marks gained by candidates who fail will not be published.

1. The examination is held annually at the Civil Engineering College, Sibpur, on the 1st Monday in June. The examination will be conducted either at the College or by an Examiner, Public Works Accounts (including Railway and Telegraph), in Bengal, Assam and Burma only. The examination will be *ipso facto* vitiated if it be not held (begun and completed) on the dates fixed, but the officer who will conduct the examination may make his own arrangements in regard to the *place* and *hour* of examination with the candidates.

Candidates will not be examined in any of the Calcutta offices.

A candidate already in permanent Government employ* may be allowed to compete in the examination even if he is more than 25 years of age, and may be appointed to an accountantship if he passes it; but if he is not already in pensionable service, he will be eligible only for appointment to the non-pensionable establishment on State Railways.

* This term includes employment under Local Boards and foreign bodies if such is pensionable by the British Government.

2. The candidate should apply to an Examiner of Public Works Accounts not later than 30 days previous to the date fixed for the examination, and obtain his consent to conduct the examination, if examination at the College is not convenient. The application must bear the address of the candidate, must be accompanied by a fee of Rs. 10 and the following certificates, and must be forwarded by him not direct to the Principal, but through the Examiner.

Certificates may be submitted in original, or true copies attested by an officer of the Engineer or Accounts Branch, but none will be returned:—

(1) Certificate of good character signed by applicant's immediate official superior or by the instructor under whom he has been educated, or by some other superior under whom he may have been brought up or employed, or to whom he may be well known. (This certificate must have special reference to the two years immediately preceding the application.)

(2) Certificate of age (baptismal or of birth not required if the candidate is already in permanent Government employ).

(3) Certificate that the application is in the candidate's handwriting.

It will rest with the Examiner of Accounts, to whom the candidate submits his application, on a consideration of these certificates, to decide whether the candidate should be registered for the examination or whether his application should be rejected. He will only forward the names of accepted candidates to the Principal together with their applications in their own handwriting, statement of their ages, and fees. These should be transmitted altogether under one covering letter on the last day allowed by the rule.

3. Examination papers that are issued for examination need not be returned.

4. Each examination is complete in itself. A candidate who has failed in an examination, and presents himself for examination on a subsequent occasion must undergo the full examination and furnish fresh fee and certificates.

5. Passed candidates should apply, not to the Principal of the College, nor to the Accountant-General, Public Works Department, but direct to the Examiner of Public Works Accounts in the province or railway under whom they may desire to be employed.

6. It must be distinctly understood that the passing of this examination does not give any claim to an appointment, and that in making appointments preference will be given to qualified persons who are already employed in the department.

7. The Civil Engineering College acts solely as an examining body in reference to admission to the 4th grade of Accountants, Public Works Department.

ACCOUNTANTS.

4TH GRADE ACCOUNTANTS.

	NAME.	Year.	REMARKS.
	1	2	3
	Chandi Charan Ghose ...	1866	
	Haran Chundra Bose ...	1866	
	Womesh Chandra Chatterjee	1866	
	Nundo Lal Sen ...	1866	
5	Bhoobun Mohan Chatterjee ...	1866	
	Mohendra Nath Chatterjee ...	1866	
	Dwarka Nath Pal ...	1866	
	Chandra Nath Simlye' ,, ...	1866	
	Ram Kamal Sircar ...	1866	
10	Nilmadhub De ...	1866	
	Kally Kamal Sircar ...	1866	
	Gopal Gobindo Chowdry ...	1866	
	Mohesh Chandra Bose ...	1866	
	Sreenath Ghose ...	1866	
15	Sasthi Charan Mittra ...	1866	
	W. Fleming ...	1866	
	A. Rangiyald ...	1866	
	Sashidhur Baruah ...	1866	
	R. H. Smith ...	1866	
20	Norman Andrews ...	1867	
	Issan Chundra Mittra ...	1867	
	Nundo Lal Mukerjee ...	1867	
	Koylas Chundra Chatterjee ...	1867	
	William Jones ...	1867	
25	Soorji Kumar Banerjee ...	1867	
	Daniel Pereira ...	1867	
	Richard M. Slane ...	1867	
	E. A. Coello ...	1867	
	George A. Laval ...	1867	
30	F. W. Hurst ...	1867	
	J. Jacob ...	1867	
	W. Martin ...	1867	
	W. P. Kelly ...	1867	
	Kally Gopal Mukerjee ...	1867	
35	Kala Chand Mukerjee ...	1867	
	Gopal Chandra Dutta ...	1868	
	Bonomally Chatterjee ...	1868	
	J. H. Richards ...	1868	
	Radharaman Set ...	1868	
40	Tarini Charan Chatterjee ...	1868	
	Womesh Chandra Ghosh ...	1868	
	C. E. Jacobs ...	1868	
	Aloysius D. Reddie ...	1868	
	Ambica Charan Chatterjee ...	1868	
45	Kally Prosonno Banerjee ...	1868	
	A. Calder ...	1868	
	Bundiram Chatterjee ...	1868	
	Gopal Chundra Dass ...	1868	
	Jagat Chundra Shome ...	1868	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	Ashutosh Mittra ...	1868	
	Nibaran Chundra Chatterjee.	1868	
	Poorno Chundra Bhuttacharjee	1868	
	R. A. Coello ...	1868	
	Juggobandhu De ...	1869	
55	Nundo Lall Bhuttacharjee ...	1869	
	Prassonno Kumar Pal ...	1869	
	Bholanath Dass ...	1869	
	Debendra Nath Mullik ...	1869	
	Jadunath Pal ...	1869	
60	Kally Krishna Chatterjee ...	1869	
	William Thomson ...	1869	
	Andrew Bald ...	1869	
	Womesh Chandra Mukerjee ...	1869	
	W. McReddie ...	1869	
65	W. N. Shilstone ...	1869	
	J. D. Gregory ...	1869	
	Indraram Baruah ...	1869	
	J. R. Coles ...	1870	
	Kally Prosonno Roy ...	1870	
70	Ramram Dutt ...	1870	
	Shyam Sundra Patnaik ...	1870	
	Bhoggobutty Charan Mukerjee	1870	
	Prossonno Kumar Dutt ...	1870	
	Durga Charan Banerjee ...	1870	
75	Lal Mohan Dass ...	1870	
	Girish Chandra Deb ...	1870	
	Radha Mohan Dass ...	1870	
	C. A. James ...	1870	
	R. DeCruze ...	1870	
80	H. J. A. Palmer ...	1870	
	Woma Charan Mitra ...	1870	
	Aghore Nath Ghosal ...	1870	
	Radhika Prosad Sircar ...	1870	
	Ambika Charan Mittra ...	1870	
85	Ishan Chandra Dutt ...	1870	
	J. A. Freitus ...	1870	
	Ishan Chandra Kundu ...	1870	
	Kshettra Mohan Tarafdar ...	1871	
	Kanti Chundra Mukherjee ...	1871	
90	Dwarkanath Sen ...	1871	
	Rishnu Charan Mukerjee ...	1871	
	A. Percy ...	1871	
	J. W. Bridge ...	1871	
	Shyama Charan Ghose ...	1871	
95	Chundra Nath Banerjee ...	1871	
	A. Wilson ...	1871	
	C. F. Stevens ...	1871	
	Debendra Nath Dutt ...	1871	
	H. C. Kingh ...	1871	
100	Geo. Lambert ...	1872	
	Mohendra Nath Chatterjee ...	1872	
	A. R. Kalberer ...	1872	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	Ghoneshyam Bhuttacharjee ...	1872	
	Satcowry Mukerjee ...	1873	
105	E. Lumsden ...	1873	
	Akhil Chandra Mukerjee ...	1873	
	A. A. Daniel ...	1873	
	Jadu Nath Chatterjee ...	1873	
	E. J. P. Fynn ...	1873	
110	Brojo Mohan Aditya ...	1873	
	Bhibiram ...	1873	
	Poorno Chandra Sen ...	1873	
	Rameswar Dass ...	1873	
	Bidhinath Chatterjee ...	1873	
115	Mohima Chundra Bhadu ...	1873	
	J. F. Chew ...	1873	
	T. T. Durmalingum ...	1873	
	Gopi Mohan Banerjee ...	1873	
	Pasupati Charan Bose ...	1873	
120	Krishna Chundra Bose ...	1873	
	Madan Mohan Ghose ...	1873	
	Sidhesswar Bose ...	1873	
	Raj Kissen Ghose ...	1873	
	H. O. Daniel ...	1873	
125	Ashutosh Singha ...	1873	
	Edward Hyde Phillips ...	1873	
	Kally Krishna Ghosal ...	1873	
	Bidhubhusan Mukerjee ...	1873	
	Isaac Purnanundo Roy ...	1873	
130	E. P. O'Conner ...	1873	
	Womesh Chandra Pal ...	1874	
	Sodanando Behera ...	1874	
	Chandra Kanta Ghose ...	1874	
	Moonshi Abdul Burr ...	1874	
135	Sashi Sikhar Banerjee ...	1874	
	Nundo Lal Mukerjee ...	1874	
	Kally Charan Mittra ...	1874	
	Krishna Kumar Sen ...	1874	
	Jas. Alfred Pain ...	1874	
140	Eugene Cox ...	1874	
	Adya Nath Mittra ...	1874	
	Ramdas Sircar ...	1874	
	Raj Mohan Ganguli ...	1874	
	Shyama Charan Ghose ...	1874	
145	Kartikeya Biswas ...	1874	
	Sarat Chandra Chakraverti ...	1874	
	Debendra Nath Mukerjee ...	1874	
	Ashutosh Bose ...	1874	
	C. H. Ramanua Naidu ...	1874	
150	Bootee Lal ...	1874	
	Nilambar Bose ...	1875	
	Bhutnath Mukerjee ...	1875	
	Banimadhub Mukerjee ...	1875	
	Kunia Behari Dutt ...	1875	
155	Akshoy Kumar Ghose ...	1875	
	Dwarkanath Chatterjee ...	1875	

4TH GRADE ACCOUNTANTS—*continued.*

	NAMES.	Year.	REMARKS.
	1	2	3
	Walter R. Monks ...	1875	
	J. S. Johnstone ...	1875	
	Nundolal Dass ...	1875	
160	Satya Charan Chatterjee ...	1875	
	Henry Arthur Nelson ...	1875	
	Upendra Nath Ganguli ...	1875	
	Nemai Charan De ...	1875	
	John Simpson ...	1875	
165	Kedar Nath Chakraverti ...	1875	
	Sarat Chandra Moozomdar ...	1875	
	Saroda Prosad Chatterjee ...	1875	
	Ambika Charan Sircar ...	1875	
	Brojonath Bhuttacharjee ...	1875	
170	Golab Chand Lal ...	1875	
	Sarat Chandra Roy ...	1875	
	Hem Chandra Ghose ...	1875	
	Purna Chandra Bose ...	1875	
	Madho Roy Ganesh ...	1875	
175	S. G. A. Phillips ...	1875	
	Kissori Bollov Roy ...	1875	
	Woma Charan Banerjee ...	1875	
	Gopal Chandra Dutt ...	1875	
	Nilratna Banerjee ...	1876	
180	Sitala Charan Ghose ...	1876	
	Abdur Rubb ...	1876	
	Kally Bhusan Banerjee ...	1876	
	Upendra Nath Dutt ...	1876	
	Janoki Prosad Tewari ...	1876	
185	Anando Naik ...	1876	
	Phillip Macklin Flanney ...	1876	
	Bhudar Banerjee ...	1876	
	Ananda Gopal Guin ...	1876	
	Dimbadhur Dass ...	1876	
190	Kedarnath Dass ...	1876	
	George P. Pritchard ...	1876	
	P. G. Jordan ...	1876	
	Annoda Charan Rose ...	1876	
	Arthur William Namey ...	1876	
195	Sylvester Herbert ...	1876	
	Akchoy Chandra Karmokar ...	1876	
	Nobin Chandra Banerjee ...	1876	
	Samuel Hammond Watling ...	1876	
	H. Leonard ...	1876	
200	Kedar Nath Ghose ...	1876	
	William Hart ...	1876	
	E. H. Telfer ...	1876	
	John Martin Sarkies ...	1876	
	W. C. Phillips ...	1876	
205	Mohamed Akrum ...	1876	
	Kirtiram Boruah ...	1876	
	Shib Chandra Dutt ...	1876	
	Ambika Charan Chatterjee ...	1876	
	Hem Kally Chatterjee ...	1876	
210	Hari Charan Sircar ...	1876	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	K. Sunderramiah Pantolu ...	1877	
	Jas. Schofield ...	1877	
	C. Visnanadhuna Moodelier ...	1877	
	Bamapodo Roy ...	1877	
215	Gopal Chundra Dutt ...	1877	
	G. Ewing ...	1877	
	Kshettra Nath Banerjee ...	1877	
	Francis T. G. Valker ...	1877	
	Sidhesswar Bose ...	1877	
220	Bama Charan Dutt ...	1877	
	Shiv Krishna Purdit ...	1877	
	Abinas Chundra Banerjee ...	1877	
	James Grassmann ...	1877	
	Purusottam Bhuttacherjee ...	1877	
225	M. G. Lackersteen ...	1877	
	Jogendra Chundra Deb ...	1877	
	Nursing Chundra Banerjee ...	1877	
	Saroda Prosad Mittra ...	1877	
	R. A. Freitas ...	1877	
230	M. V. Muttusami Iyer ...	1877	
	Anthony Bernard Mariano ...	1877	
	William Baran Twidale ...	1877	
	Annoda Prosad Mukerjee ...	1877	
	Joggeshwar Ghose ...	1877	
235	Jogesh Chundra Mukerjee ...	1877	
	John Edwin Cooney ...	1878	
	Chundra Nath Mittra ...	1878	
	Francis Walter Eicke ...	1878	
	Radhagobindo Bysak ...	1878	
240	Khiroda Kumar Sing ...	1878	
	Trailokya Nath Chakraverti ...	1878	
	Haripodo Chatterjee ...	1878	
	Amullyaratan Mukerjee ...	1878	
	Raja Ram ...	1878	
245	Bishnu Das ...	1878	
	Bhairo Sahay ...	1878	
	Rai Beshoon Dutt ...	1878	
	Tincowry Ghose ...	1878	
	Alexander Diniveddie ...	1878	
250	Imam Bux ...	1878	
	Goordit Mull ...	1878	
	C. R. Dela Hayde ...	1878	
	Michael J. Senaes ...	1878	
	Chundra Kanta Bose ...	1878	
255	Nutt Mull ...	1878	
	Dobendra Nath Chakraverti ...	1878	
	William Thomas Middleton ...	1878	
	Grant Nicholas ...	1878	
	H. P. Dick ...	1878	
260	Ambika Charan Banerjee ...	1878	
	Radhanath Roy Chowdry ...	1878	
	Protap Chundra Gupta ...	1878	
	Haridas Roy ...	1878	
	Atul Krishna Mukerjee ...	1878	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
265	Kshettra Nath Bose ...	1878	
	H. A. Campbell ...	1878	
	C. D. Howard ...	1878	
	Bama Charan Ghose ...	1878	
	Rai Charan Chatterjee ...	1878	
270	Hari Mohan Banerjee ...	1878	
	J. A. Farrell ...	1878	
	Frederick Pruce ...	1878	
	Mangu Ram ...	1878	
	Shyama Charan Chakraverti...	1878	
275	Jadub Chundra Bhomik ...	1878	
	Bani Madhub Chatterjee ...	1878	
	Shyama Prosad Roy ...	1878	
	Nritya Gopal Bose ...	1878	
	Upendra Nath Mittra ...	1878	
280	Charles Thomas D'Souza ...	1878	
	Seetaram Sen ...	1878	
	Bhogobutty Charan Chatterjee	1878	
	Arthur Strachan Wyman ...	1879	
	George Johnstone ...	1879	
285	William N. Ryan ...	1879	
	Haradev Prasada ...	1879	
	Upendra Nath Banerjee ...	1879	
	Bowhani Charan Mittra ...	1879	
	Fred. W. Rogers ...	1879	
290	Kumud Nath Chatterjee ...	1879	
	Goneshi Lal ...	1879	
	Nobogopal Singha ...	1879	
	Nepal Chundra Mukerjee ...	1879	
	Tincowry Chatterjee ...	1879	
295	Edward Welton Dover ...	1879	
	Fred Charles Welton Dover...	1879	
	Bhutnath De ...	1879	
	Edward Marshall ...	1879	
	Harprosad Pundit ...	1879	
300	Prosadi Lal ...	1879	
	Chnni Lal ...	1879	
	Ernest Blewett ...	1879	
	Kissori Mohan Sanyel ...	1879	
	Sarat Chundra Mittra ...	1879	
305	James Maurice Hartmann Swiney.	1879	
	Panch Cowry Ghose ...	1879	
	Edmond James Chas Dundon	1879	
	H. Ewing ...	1879	
	Prankrishna Mukerjee ...	1879	
310	Brojendra Kumar Sircar ...	1879	
	Kheroda Prosad Banerjee ...	1879	
	Ramjeban Ghose ...	1879	
	Umaprosad Roy ...	1879	
	Jagodishwar Bose ...	1879	
315	Manna Lal ...	1879	
	Trekimlal Kesowlal ...	1879	
	Kedar Nath Chatterjee ...	1879	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	YEAR.	REMARK.
	1	2	3
	Annoda Prosad Banerje ...	1879	
	Durgadas Banerjee ...	1879	
320	S. O. Shaughnessy ...	1879	
	Lakshiram ...	1879	
	G. Evans ...	1879	
	Chundra Kanta Promanik ...	1879	
	Gouri Ram ...	1879	
325	Madho Ram ...	1879	
	Basanto Kumar Mukerjee ...	1879	
	Mainickjee Burjuijee ...	1879	
	Gangadhar Anant ...	1879	
	James Johannes ...	1879	
330	Shyama Charan Ghose ...	1879	
	Charles Wight ...	1879	
	Roger N. Beveridge ...	1879	
	V. Solomon ...	1879	
	Girish Chandra Nag Sircar ...	1879	
335	Arthur Andrews ...	1880	
	Prosonno Kumar Sen ...	1880	
	Jonardon Mukerjee ...	1880	
	Janakinath Roy ...	1880	
	Kally Prosonna Roy ...	1880	
340	Ramranjan Mukerjee ...	1880	
	Baladeb Gosain ...	1880	
	Assini Kumar Bose ...	1880	
	William Joseph Burvett ...	1880	
	Frederick Stuart Porter ...	1880	
345	Paramessari Dass ...	1880	
	Jowala Singh ...	1880	
	Ram Chand ...	1880	
	Narain Singh ...	1880	
	Memnanjee Fundoojee ...	1880	
350	Srish Chundra Ghose ...	1880	
	John Joseph McCann ...	1880	
	Bama Charan De ...	1880	
	Bejoygovindo Chowdry ...	1880	
	Soshi Bhusan Bhuttacharjee	1880	
355	Sarada Prosad Bhattacharjee	1880	
	Lalla Nanak Chand ...	1880	
	Shangsor Chander Banerjee ...	1880	
	Gustadji Dhanjishah Kagsadia	1880	
	Albert Clifford Owen ...	1880	
360	Sarabjee Bamanjee ...	1880	
	Abhoy Charan Roy ...	1880	
	Choony Lall Magan Lall ...	1880	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Ram Chander Bhote ...	1880	
	James D. Rozario ...	1880	
365	T. McCann ...	1880	
	Uma Prosad Bagchi ...	1880	
	Amrito Lall Bose ...	1880	
	Notobor Mukerjee ...	1880	
	Nondo Lall Bhattacharjee ...	1881	
370	Sidheswar Roy ...	1881	
	W. J. Dunn ...	1881	

4TH GRADE ACCOUNTANTS—*continued.*

	NAMES.	Year.	REMARKS.
	1	2	3
	Mohendro Nath Roy ...	1881	
	Dwarka Nauth Sen ...	1881	
	Kedar Nauth Biswas ...	1881	
375	David O'Dowda ...	1881	
	George Augustus Damzen ...	1881	
	Aghore Nauth Dutt ...	1881	
	Nobin Krisna Bhattacharjee ...	1881	
	Uma Sankar ...	1881	
380	J. Corrigan ...	1881	
	Kamikhya Nauth Banerjee ...	1881	
	Moolji Bhagwan Shett ...	1881	
	A. C. C. McLeish ...	1881	
	Baidya Nauth Bhattacharjee ...	1881	
385	Jogot Chander Mukerjee ...	1881	
	A. Ganguly ...	1881	
	William Kelly ...	1881	
	Gour Gopal Dey ...	1881	
	Ranga Nauth Kasi Nauth Fausi	1881	
390	Kirti Chander Chatterjee	1881	
	Ganoda Prosad Ganguly	1881	
	Francis George Harris	1881	
	Jules Bell	1881	
	Atul Krisna Dutt	1881	
395	Behari Lal Chatterjee	1881	
	T. Subramoney Aun	1881	
	Arthur McLean	1881	Passed under section IV, paragraphs 59 and 60, Chapter II, W. P. D. Code of 1878.
	Keshub Chander Singhi	1881	
	Dasorothi Banerjee	1881	
400	Lalla Mulk Roy	1882	
	Amor Nauth Ganguly	1882	
	F. W. McGrath	1882	
	Richard Frederick Drame	1882	
	Lalla Nibu Ram	1882	
405	Pundit Gopi Nauth	1882	
	Sree Nauth Mittra	1882	
	Keshob Chander Ghose	1882	
	C. Narsiah	1882	
	P. Varejanabhudu Naidu	1882	
410	Cheddi Lal	1882	
	Bhowani Charan Boral	1882	
	Shashi Bhusan Pal	1882	
	William Lemon	1882	
	E. E. Richards	1882	
415	Daniel Bates	1882	
	Upendro Nath Mittra	1882	
	Narayan Chander Roy	1882	
	John Green	1882	
	W. H. E. Turner	1882	
420	Sarat Chander Mitter	1882	
	Nezaiudin	1882	
	Autul Behary Das	1882	
	Mohini Mohon Bhattacharjee	1882	
	Oscar William Malletti ...	1882	
425	Rajendro Nauth Mukerjee ...	1882	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	YEAR.	REMARKS.
	1	2	3
	Alexander M. Carson ...	1882	
	John Thobwing ...	1882	
	Allice Alex. Philbert ...	1882	
	Sam Joachim ...	1882	
430	Cecil Joachim ...	1882	
	Vallah Hargovindo Almarram Bhuckhanwalla ...	1882	
	Shoshi Bhusan Pal ...	1882	
	Nicholas John Jebb ...	1882	
	Makhan Lal Roy ...	1882	
435	Bireswar Mukerjee ..	1882	
	John Rodda Dunn ...	1882	
	Herbert Butterfield ...	1882	
	Probodh Chander Gupta ...	1882	
	Madho Ram ...	1882	
440	Archibald Gregory ...	1882	
	Thomas Michell Shaw ..	1882	
	James Argyle Smith ...	1882	
	Reginald Peyton Dunlop Burbridge ...	1883	
	Tranada Charan Mittra ..	1883	
445	Augustus DeSouza ...	1883	
	Reginald Medlycott ...	1883	
	Nathu Jamnadas ...	1883	
	Sarat Chander Chowdhury ...	1883	
	Nobin Chander Sen ...	1883	
450	Annada Prosad Dutt ...	1883	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Richard A. Creenumey ...	1883	
	Mahomed Jalaluddin ...	1883	
	Bhogobote Charan Mukerjee ...	1883	
	Alexander Fernie ...	1883	
455	Pundit Modon Mohon ...	1883	
	Abdul Goni ...	1883	
	Shoshi Kumar Mozoomdar ...	1883	
	Kedar Nath De ...	1883	
	Hari Nauth Singha ...	1883	
460	Thakur Das ...	1883	
	Le. C. Rostan ...	1883	
	Kailaspotty Banerjee ...	1883	
	Moti Lal Mukerjee ...	1883	
	Debi Singh ...	1883	
465	Adhor Nauth Banerjee ...	1883	
	Hira Lal Roy Chowdhury ...	1883	
	James Thomas Evans ...	1883	
	J. Geo. B. Armour ...	1883	
	E. L. Mendes ...	1883	
470	Damodor Dutt ...	1883	
	Karam Chand ...	1883	
	Earnest H. D'Cruz ...	1883	
	Govindo Ram ...	1883	
	Ram Chander Chaturwedi ...	1883	
475	Chirag Deen ...	1883	
	Tarapodo Ghose ...	1883	
	James Younan ...	1883	
	Chatturbhooj Dobey ...	1883	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	Parjaram Naratam Das Adhyaree ..	1883	
480	Hari Charan Dutt	1883	
	Ram Chander Banerjee	1883	
	Pundit Niranjan Nauth	1883	
	Mul Raj Khoola	1883	
	Pundit Ishar Das	1883	
485	Bapalal Kikabhai	1883	
	Moola Ram	1883	
	Kirtibas Bhattacharjee	1883	
	Joges Chunder Chatterjee	1883	
	Louis R. St. Romaine	1883	
490	Makando Ram	1883	
	Mohon Lal	1883	
	Monohor Lal	1883	
	Hem Chunder Ghose	1883	
	A. Belletty	1883	
495	Sham Narayan	1883	
	Jamsetjee Eduljee	1883	
	Ishar Dass	1883	
	Gunda Singh Moonshi	1883	
	Tulsi Ram	1883	
500	Charles Raymond Martin	1883	
	Okhoy Kumar Roy	1883	
	Ganga Shohay	1883	
	R. Krishna Sawmey Naicker	1883	
	Sohan Lall	1884	
505	Nripendro Nath Roy	1884	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Jerome Andrew	1884	
	R. Dowling	1884	
	Ram Narain Banerjee	1884	
	Karim Baksh	1884	
510	Charles Lodrick	1884	
	Ahmed Din	1884	
	Edmond D'Rozario	1884	
	Troylukhyo Nath De ..	1884	
	Novin Chander Bhattacharjee	1884	
515	Durga Prosuda ..	1884	
	Deepa Shah	1884	
	H. C. V. Sage	1884	
	Henry Walter Fegudo	1884	
	C. Muirhead	1884	
520	Ahanto Ram	1884	
	C. S. Murphy	1884	
	Mahomed Abdoollah	1884	
	Tarapodo Ghose	1884	
	Balkrisna Trinbook	1884	
525	Dabendro Nauth Roy	1884	
	Ganga Ram	1884	
	Kassim Beg	1884	
	Barkat Alli	1884	
	Mohendro Nauth Ghose	1884	
530	W. W. De Lattoyde	1884	
	Debi Doyal	1884	
	C. L. Jose	1884	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	Gowri Ditta ...	1884	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Barada Kanta Chowdhury ...	1884	
535	Khetra Mohon Bose ...	1884	
	Troylukyo Nauth Chakerbutty	1884	
	Hakim Din ...	1884	
	V. E. Nepos ...	1884	
	Frederic Chaplin Nisbet ...	1884	
540	Badhwa Mul ...	1884	
	Hera Nand ...	1884	
	Shyam Lal ...	1884	
	Kannyhia Lall ...	1884	
	Lakhpot Roy ...	1884	
545	Bipin Behary Dey ...	1884	
	T. Narain Swamey Pillay ...	1884	
	Madho Lall ...	1884	
	Edmund Cannon Maylan ...	1885	
	Arthur Henry Hammill ...	1885	
550	Dinshaw Manickji ...	1885	Passed under section IV, paragraphs 59 and 60, P. W. D. Code of 1878.
	Ram Lal Roy ...	1885	
	Jugal Kisore Byasack ...	1885	
	Ram Chander Govind Talvalkar	1885	
	Gopal Das ...	1885	
555	Chandra Mohon Das ...	1885	
	Dharma Das Mukerjee ...	1885	
	Herambo Nauth Chatterjee ...	1885	
	Bhutto Behary Dhor ...	1885	
	Brojo Lal Sanyel ...	1885	
560	Rama Charan Chakerbutty ...	1885	
	Amor Nauth Pandit ...	1885	
	Makhan Lal Ghose ...	1885	
	Bhola Nauth ...	1885	
	Bipin Behary Batavyal ...	1885	
565	Rajendro Nauth Banerjee ...	1885	
	Denis O'Hearn ...	1886	
	G. H. Coleman ...	1886	
	Poorna Chander Dey ...	1886	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Nil Prosonna Ghose ...	1886	
570	Kiran Chander Banerjee ...	1886	
	Rash Behary Addi ...	1886	
	Gerald Leith Godwin ...	1886	
	Bipin Behary Banerjee ...	1886	
	Poorna Chander Chatterjee ...	1886	
575	R. J. Morton ...	1886	
	Robert Walsh ...	1886	
	Bidhu Bhusan Banerjee ...	1886	
	Radha Kanto Roy ...	1886	
	Munshi Willoyut Hossain Khan	1886	
580	Debendro Nauth Bose ...	1886	
	Ashutose Neogy ...	1886	

4TH GRADE ACCOUNTANTS—*continued.*

	NAME.	Year.	REMARKS.
	1	2	3
	Robert F. George ...	1887	
	Jiban Krishna Chander ...	1887	
	Hyginus Dommerric ...	1887	
585	Gracias ...	1887	
	Bipin Behary Chandra ...	1887	
	Nil Kanto Chatterjee ...	1887	
	Girish Chander Gupta ...	1887	
	Dennis O'Sullivan ..	1887	
590	Moti Lall Sen ...	1887	
	A. D. Rozario ...	1887	
	Michael Charles Edward Dorris	1887	
	Akhoy Kumar Banerjee ...	1887	
	Arthur Joseph George ...	1887	
595	A. Rainford ...	1887	
	Leonard Colthurst ...	1887	
	John S. Riley ...	1887	
	Haraprosad ...	1887	
	Edward Bertram James ...	1887	
600	Radha Charan Banerjee ...	1887	
	Kaliprosonna Banerjee ...	1887	
	Kunjabehary Lal ...	1887	
	Mohendro Nath Das ...	1887	
	Shoshi Bhusan Dutt ...	1887	
605	Bacharam Audhicary ...	1887	
	Beniprosad ...	1887	
	Kalidas Bose ...	1887	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Uma Nauth Singh ...	1888	
	James William Fillinger ...	1888	
610	James H. Cameron ...	1888	
	Ashutosh Bhattacherjee ...	1888	
	William O'Cesar ...	1888	
	E. W. Hall ...	1888	
	George Hamilton ...	1888	
615	Shushil Kumar Bose ...	1888	
	Jogendro Kumar Bhadra ...	1888	
	Walter Harold Hodges ...	1888	
	Mihir Chander Dutt ...	1888	
	W. A. Samuel ...	1888	
620	Ashutosh Mookerjee ...	1888	
	A. Cum Sone ...	1888	
	Abinash Chander Ghosh ...	1888	
	A. Vaughan ...	1889	
	Robert Cresswell Keating ...	1889	
625	Nilmoney Bose ...	1889	
	G. Whyte ...	1889	
	T. A. Johnson ...	1889	
	Nirode Chander Mozomdar ...	1889	
	Hemadrish Chander Bhattacharjee.	1889	
630	Bhabani Charan ...	1889	
	E. Jewell ...	1889	
	A. Ben Court ...	1889	
	Albert Aukim ...	1890	
	Kalipodo Banerjee ...	1890	

4TH GRADE ACCOUNTANTS—*continued*.

	NAME.	Year.	REMARKS.
	1	2	3
635	Behary Lall Koleh	1890	
	Brij Behary Sett	1890	
	Bipin Behary Dutt	1890	
	Ujjal Chander Sen	1890	
	Bata Krisna Ghose	1890	
640	Nogendro Nath Mittra	1890	
	Robert B. Smart	1890	
	Arnold Roberts	1890	
	Stephen Robert Ewing	1890	
	Gourdas Roy	1890	
645	Nando Coomar Ganguli	1891	
	R. C. Chelliah	1891	
	Deoki Nandan Sahai	1891	
	Uma Churan Gupta	1891	
	Adya Nath Sarkar	1891	
650	J. E. Rosario	1891	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Clifford L. Colthurst	1891	
	Hem Chandra Ghose	1891	
	Surendra Nath Guha	1891	
	Haridas Tarafdar	1891	
655	Haridas Mitra	1891	
	A. S. Heberlet	1891	
	Kali Das Mookerjee	1891	
	Frank Elurja Pereira	1892	
	Chuni Lal Banerji	1892	
660	Sarat Chandra Chowdhury	1892	
	Radha Kantha Paul	1892	
	A. Ed. Texeira	1892	
	Nando Gopal Mookherjee	1892	
	Ekkari Lal Ghosh	1892	
665	Sujan Nath Basak	1892	
	William Percy Avery ...	1893	
	Andrew Hypher ...	...	
	A. Carnabe ...	...	
	Rajedro Lal Sarkar ...	...	
670	Lowis Edward James ...	...	
	H. Middleton ...	...	
	Bidhu Bhusan Banerjee ...	...	
	Aghore Nath Biswas ...	...	
	Hari Prosad Mookerjee ...	...	Passed under Appendix C, paragraphs 4 and 10 of P. W. D. Code of 1892.
675	Rameswar Pal ...	...	
	J. Rudra ...	...	
	Suraj Mohan Roy Chowdhoory ...	...	
	Stephen Simon Stephen ...	...	
	Mohendro Nath Roy ...	...	
680	Baroda Kantha Mookerjee ...	...	
	Debendro Nath Sen Gupta ...	...	
	Chuni Lal Datt ...	...	

4TH GRADE ACCOUNTANTS—*concluded.*

	NAME.	Year.	REMARKS.
	1	2	3
	Nando Lal Bose ...	1894	
	H. W. Hottinger ...	1894	
685	Akshay Kumar Banerji ...	1894	
	P. Srinavasa Naidu ...	1894	
	Saroje Nath Bagchi ...	1894	
	Promotha Nath Dutt ...	1894	
	William Duncan Small ...	1894	
690	Herbert Jasper DeLange ...	1894	
	Francis Christy Rosair ...	1894	
	M. Swamynathan ...	1894	
	Nirmul Chander Bhaduri ...	1894	
	Haro Mohan Dey ...	1894	
695	Sadhu Charan Mookerji ...	1894	
	Jnan Ranjan Guha ...	1895	
	Annoda Pada Mukerjea ...	1895	
	Arthur Robert Lambs ...	1895	
	Srish Chandra Mitra ...	1895	
700	Sita Ram Yadubansi ...	1895	
	Richard E. Mitter ...	1895	
	Chandra Mohan De ...	1895	
	Mohini Mohan Roy ...	1895	
	T. K. Dutt ...	1895	
705	Lalit Mohan Chandra ...	1895	
	Abdur Rubb ...	1895	
	Gopi Mohan Aditya ...	1895	
	Poresh Nath Mukerjea ...	1895	
	George Richard Fitz Patrick ...	1895	
710	Nogendra Nath Das Gupta ...	1895	Passed under Appendix C, paragraphs 4 and 10 of P. W. D. Code of 1892.
	Alexander Thomas Samuells ...	1895	
	Harihar Banerjea ...	1895	
	Rasik Lal Mallik ...	1895	
	Sadananda Ghosh ...	1895	
715	Satinath Sircar ...	1895	
	Swami Atma Ram ...	1896	
	Elias B. Cohen ...	1896	
	John Robert Frederick Fitzherbert	1896	
	Khetra Nath Mitra ...	1896	
720	Thomas E. McCullogh ...	1896	
	R. N. Mitra ...	1896	
	Nagendra Nath Mukerjee ...	1896	
	Sris Chander Roy ...	1896	
	John M. Peal ...	1896	
725	Lakshmi Narain Sen ...	1896	
	James O. Eving ...	1896	
	Surendra Nath Chuckerbutty ...	1896	
	Clarence DeSouza ...	1896	
	Satyendra Kumar Sen ...	1896	
730	C. Dessent ...	1896	
	Kshetrahari Chatterjee ...	1896	
	Charles C. Potinger ...	1896	
	Rakhal Chander Das ...	1896	
	Anukul Chander Sen Gupta ...	1896	
735	Maya Das ...	1896	
	Rohini Kumar Sen ...	1896	

CIVIL ENGINEERING COLLEGE, SIBPUR.

ANNUAL REPORT, 1895-96.

ENGINEER DEPARTMENT.

THE following Table shows the number of students in the Engineer Department on 1st April 1895:—

CLASS.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.
1	2	3	4	5
1st year	24	...	3	27
2nd „	34	1	...	35
3rd „	22	1	...	23
4th „	12	...	...	12
Total ...	92	2	3	97

Table showing the number of passes and failures at the College and University Examinations in 1895-96.

EXAMINATION.	Number of candidates.	Number absent.	Number of passes.	Failures.		Total failures.	Percentage of passes.	REMARKS.
				Class.	Shops.			
1	2	3	4	5	6	7	8	9
B. E.	12	...	3	...	..	9	25	2nd Division
L. E.	12	.	3	...	...	9	25	Ditto
F. E.	32	...	11	...	...	21	34·4	One 1st Division. Rest 2nd Division.
2nd year	35	...	27	8	...	8	77·1	
1st „	27	1	23	3	...	3	88·5	

B. E. and L. E. Examination.—The University Examination for Engineering Degrees began on the 8th July. The results, as will appear from the above Tables, were not satisfactory, only 25 per cent. of the candidates having passed. Better results would be obtained if the questions were carefully moderated. In some instances the papers set are too long, and it is no uncommon occurrence to find in a paper of, say, 10 questions, one or two questions which would take up the full time of the candidates to answer thoroughly. Seeing their inability to get through the paper, the students get flustered and do not do themselves justice. This state of affairs must continue, as the University does not appear to be able to engage the services of Examiners in Engineering subjects, who have had any previous training in the art of examining.

The guaranteed appointment was secured by Amar Nath Das, B.E., who also gained the Ambika Charan Chaudhuri gold medal and the Trevor silver medal. In addition to the appointment given to Srish Chunder Chakraverti, as mentioned in my last year's Report, the Government of India appointed Poresh Charan Chatterji, B.E., who took his degree in 1894, as an Apprentice Engineer in the Public Works Department. Last year's graduates are now undergoing a one year's course of practical training under the Public Works Department, with the exception of Romesh Chunder Das who, having accepted a mining scholarship, is serving his time in the East Indian Railway Collieries at Giridih.

F. E. Examination.—This Examination was held in April, and the result calls for no special comment. The remarks, however, regarding the Examiners appointed for the B. E. Examination, apply equally to this one.

Annual Examination.—The Annual Examination of the 1st and 2nd-year classes was held in May, and the results were very satisfactory. It is worthy of note that none of the candidates failed in the practical examination in the workshops. This is in some measure to be attributed to the greater attention it is now possible to give the students in a purely educational workshop. The number of applications for admission was 104, of whom 36 were admitted to the 1st-year class and 9 B course B A., who were admitted to the 2nd-year class.

The 1st-year class opened with 37 students, one of whom was a re-admitted failure, and the rest new students. Eight have since left, so the number in this class on the 31st March 1896 was 29.

The 2nd-year class opened with 37 students, of whom 23 were promoted from the 1st year, 5 were re-admitted, and 9 were new B course B As. One student has since left, so the number at the end of the year was 36.

The 3rd year class consists of 30 students, of whom 27 were promoted from the 2nd-year and 3 were re-admitted.

The 4th-year class consists of 11 students, all of whom passed the last F. E. Examination.

The subjoined Table gives the state of the Engineer Department on the 31st March 1896:—

Class.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.
1	2	3	4	5
1st year	28	1	...	29
2nd „	33	...	3	36
3rd „	28	2	...	30
4th „	11	...	...	11
Total ...	100	3	3	106

These figures show an increase of nine students during the year.

APPRENTICE DEPARTMENT.

The following Table shows the strength of the Apprentice Department on 1st April 1895:—

Classes.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.	Remarks.
1	2	3	4	5	6
1st year ...	44	21	...	65	
2nd „ ...	60	6	1	67	
3rd „ ...	33	3	...	36	
4th „ ...	16	3	...	19	
5th (Junior) ...	11	7	1	19	
5th (Senior) ...	1	...	...	1	
Total ...	165	40	2	207	

Under a recent ruling of the Government of India only one guaranteed appointment as 3rd grade Overseer in the non-pensionable establishment of the Railway Branch is given yearly, instead of two. The prospects held out in this appointment are not sufficiently good to induce the best European and Eurasian students to accept it. In 1895 W. Gardiner, who was first on the list, refused it, and in the year under review W. Viney, who was entitled to the appointment, declined to take it, so it was awarded to the next student, Sris Chandra Nundi. Both the European students obtained suitable employment in private Engineering Firms in Calcutta, on salaries of Rs. 150 and 200 a month, whereas the Government appointment only carries with it the pay of Rs. 60 a month, and no pension. As long as this rule is in force the best European and Eurasian students will get employment in Private Firms, which is no doubt advantageous for these Firms, but it seems to be a pity that Government cannot, after being at the expense of their education, entice some of them to join their service. Out of the last batch of seven European Apprentices who left in February, six are now employed as follows:—One in a Calcutta Engineering Firm, one in the India General Steam Navigation Boat Yard, one in a Private Engineering Firm near Darjeeling, two by the East Indian Railway, one as Assistant Engineer on a tea garden, and it is not known whether the remaining one has an appointment or not. Every one of these men would have been a useful subordinate on Railways, especially on frontier work, but they will not join Government Service on a salary insufficient to support them.

Table showing the number of passes and failures at the Annual Examination.

Examination.	Number of candidates.	Number absent.	Number of passes.	Failures.		Total failures.	Percentage of passes.	Remarks.
				Class.	Workshops.			
1	2	3	4	5	6	7	8	9
1st year	61	...	51	...	10	10	83·6	
2nd ,, ...	65	...	57	...	8	8	87·7	
Bihar Industrial School.	11	...	9	2	2	2	81·8	
3rd year	36	...	36	...	...	...	100	
4th ,, ...	18	...	18	...	...	...	100	

These results are very satisfactory. In class work the good results are to be attributed to greater continuity in the Instruction Staff, and in the Workshops to greater supervision than was possible when the practical training of the students was under the Public Works Department.

Admission.—The number of applications for admission received from qualified candidates was 80, of whom 47 were admitted, and seven old students were re-admitted. Of the new apprentices, seven had passed the University Entrance Examination in the first division, 24 in the second division, and eight in the third division; eight had passed the VIIth Standard for European Schools. The first-year class, therefore, opened with 54 students.

Reduced fee and free lists.—These lists for both Christians and natives are full.

Certificates.—Under Rules 10 and 11 of the Apprentice Department, 10 Sub-overseers' certificates were granted to Apprentices leaving the College before the completion of their apprenticeship. Besides these, 13 certificates were given to Engineer students and 12 to Apprentices who had only completed a part of their course. Seven College certificates were also granted to students who failed to pass the L. E. and B. E. Examinations, but who had completed their course of instruction.

The following Table shows the strength of the Apprentice Department on 31st March 1896.

Class.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.	Remarks.
1	2	3	4	5	6
1st year ...	40	9	1	50	
2nd ,, ...	43	17	...	60	
3rd ,, ...	44	7	2	53	
4th ,, ...	32	3	...	35	
5th Junior ...	14	3	...	17	
5th Senior ...	...	...	...	...	
Total ...	173	39	3	215	

This shows an increase of eight on the figures for the year, notwithstanding that the first year class was below its sanctioned strength.

Artisans.—This class is in process of formation, and no definite rules are drawn up as to length of course, as in the case of the other departments of the College. The object of this class is to train workmen up to a certain degree of efficiency in any particular line. At present the equipment of the College Shops only permits of their being trained as carpenters, joiners, blacksmiths, fitters, or moulders. The artisans hitherto received have been sent to have a further course of instruction in either the carpenter's or blacksmith's shop, and their skill, on admission to the College, in the particular branch in which they require further instruction, regulates the time it is necessary to keep them, to enable them to gain the requisite finish. The numbers are at present small, but it is a department which will gradually expand. Hitherto there has been no provision made in the budget for their training, but this year a grant of Rs. 1,000 has been sanctioned, out of which I hope to be able to do more work than heretofore, and, if possible, add instruction in drawing and estimating. In the formation of this Class it is necessary to proceed with great caution. The present policy is to receive boys from affiliated technical schools only, for a particular finishing course, and during the year three lads were received from the Ranchi Technical School, who have since returned to their own district, and are, I believe, instructing in small Industrial Schools in remote villages in Lohardaga. Other boys are being trained, as will be seen from the Table given below for other districts in Bengal, and if their services can be utilized in a similar manner, this Department will supply a distinct want, as artisans thus trained will be men who can earn their living at the trade selected by them. One difficulty experienced is the selection of candidates; it is of great importance to reject any who do not intend to follow the trade they are taught, and I have already refused admissions to this Department in the case of applicants who have passed either the Entrance or F. A. Examination of the Calcutta University. I do not propose to draw up any definite Rules in connection with this Department, as it appears to be better to let it gradually develop, during which time the requirements of the Province for this class of labour will be better understood.

The following Table shows the strength and distribution of this Department on 31st March 1896:—

Affiliated School from which received.	Carpenter's shop.	Blacksmiths.	Fitters.	Foundry.	Total.
1	2	3	4	5	6
Bishop's College ...	4	1	...	...	5
Bihar Industrial School	...	6	...	...	6
Mymensingh ...	1	1	...	...	2
Total ...	5	8	...	...	13

Special students.—The two students sent by the East Indian Railway Company to learn Chemistry, with special reference to the analysis of iron and steel, are still in the College. Considerable difficulty has been experienced in carrying on their instruction for want of proper apparatus. It was originally proposed that the East Indian Railway Company should purchase the necessary apparatus which would be used for the instruction of the students while here, and, on the completion of their course be transferred to Jamalpur to form the nucleus of a laboratory there. This proposal received the approval of the Government of India and the local Railway authorities, but I regret to have to record that the Board of Directors in London, acting on what appears to be ill-advised professional opinion, so mutilated the original indent, as to render it practically worthless. An unlooked for strain has therefore been brought to bear on the limited resources in the way of apparatus at the disposal of the Professor of Chemistry, and he has had a difficult task to teach the special students with the odds and ends of apparatus he could spare, without interfering with the instruction of the College classes. This short-sighted policy on the part of Directors will result in our sending out men to help to work up the new steel branch in the Jamalpur Workshops, with less experience than they would have got with a proper equipment.

Accounts Examination.—This examination was held in June. There were 125 candidates examined, of whom 20 passed.

College staff.—Mr. Macdonell returned from furlough in November and took over charge from his *locum tenens*, Mr. Gilliland. Mr. W. Tate was appointed during the year by the Secretary of State as Professor of Chemistry, and joined the College in January. He also supervises the drawing classes of the College, the officiating teacher, Babu S. K. Basu, acting as his Assistant. A new appointment was sanctioned during the year to enable Babu S. K. Basu to continue as General Assistant in the drawing school, and Babu Chuni Lal Sarkar, who was acting as a temporary teacher, has been confirmed.

I regret to have to record the death of Babu Dwarka Nath Datta, officiating teacher of drawing. By his death the College has lost the services of a hard-working officer, whose zeal in his work earned the approbation of his superiors, and whose courteous and kindly bearing endeared him to his pupils. He had been in the College for 22 years, and his sudden death is felt as a great loss. As an instance of the zealous way he conducted his duties, I may mention that (notwithstanding his weak condition) he was checking marks up to within two hours of his death, in order that the College routine might not be interfered herewith, and his marks be sent in time. Mr. Heaton's case, referred to in previous Reports, is still undecided. The question is now before Government, and I trust that in deciding it, the interests of the College may not be overlooked. The temptation to Government to use the College as a training ground, by appointing temporary Professors, is very great, as the Officers so trained are of more use to the Public Works Department after their training as Officiating Professors than they were before, but as I have at various times pointed out, this training is effected at the expense of the students; these Officiating Professors are supposed to teach while they are

learning their new duties, and the College, instead of advancing with the times, which it would do if the Professor was not learning his work, lags behind until the Professor in training is in a position to advance his instruction.

What is required is to appoint an Officer whose business in life it will be to learn thoroughly the duties of a Professor, and not to transfer one from the Public Works Department temporarily, to enable him to brush up the subjects he is rusty in.

Buildings.—The College buildings were partially repaired during the year, iron girders being used to replace old rotten beams. The amount that has been spent on repairs, however, is not sufficient to render the buildings safe, as a good deal of the woodwork in the roof is absolutely rotten. Quite recently, after the repairs for the year were finished, a joist in the Engineer Students Quarters fell from the roof, and it was found to be a mere shell, the whole of the inside having been eaten away. This joist is now in the model room, and serves to illustrate the necessity for careful inspection when repair estimates are framed. Since this accident was reported to the Public Works Department, several beams have been removed and replaced by iron ones, but the College is still far from safe, and the woodwork requires special attention.

During the year, quarters were sanctioned for the (i) two Foremen Instructors, and (ii) the Superintendent of the Hindu Mess, compounders, and Head Laboratory Assistant. These buildings are nearly finished. A mess house for Muhammadan students was completed, and it is now possible to receive Muhammadan boarders, who have not to waste their time in cooking their own food. This addition to the College may be the means of inducing more Muhammadan students to go in for an Engineering Education. Other minor works completed were (i) a drain round the new Chemical Laboratory (ii) a latrine near the Workshops, (iii) a verandah to the south of the new Chemical Laboratory. These works were done by the Public Works Department.

Administrative sanction was received for various urgent petty works aggregating Rs. 6,799, which will be completed during the coming year by the Public Works Department.

Towards the close of the year Rs. 12,000 were sanctioned for ceilings in the Chemical and Physical Laboratories and for furniture. This work is being done, partly by contract, and partly by the aid of the students. The sum asked for was based on my own estimates, and its expenditure has given me considerable anxiety, as the margin of profit allowed is so small that I have had to proceed with great caution to keep within the sanction. Some idea of the difficulties to be encountered in working within the estimate may be formed, when it is mentioned that, for the ceiling alone, tenders were received which would have practically absorbed the whole estimate. I have therefore been obliged to lay in large stocks of timber and to arrange to do most of the work with the agency at my disposal, and the training which the students are now getting will be of great value to them; but the work is not progressing as fast as is desirable. However, I see my way to getting into the Physical Laboratory early in June. The Chemical Laboratory,

however, requires more work to be done to it, and I do not think the classes will be held there for several months.

Electric lighting.—A sum of Rs. 80,000 was sanctioned for a complete installation, and the erection will be done in the coming year by a Firm of Contractors in Calcutta. The greatest care was taken by Mr. Brühl, Professor of Science, to include various types of engines, dynamos, cells, &c., so as to give as wide a range of instruction to the students when the plant is at work. It is hoped that the plant will be in working order in a few months. The cost of working expenses will be practically met from charges it is proposed to introduce for the lighting, the Professors, Students, Messes, etc., contributing to defray the cost.

Mining Scholars.—For the last three years, since it was proposed to establish these scholarships, no students have come forward for this class of training, and there is a reference to this effect in my Report of last year. During the year under review, however, one student has voluntered for this work, and is now, after graduating in Engineering, undergoing training in the East Indian Railway Colliery at Giridih. According to the present rules a mining scholar must be a graduate in Engineering of the Calcutta University, and now that a graduate has been induced to go in for this work, it is possible that others may follow in his footsteps, but I fear that many will not be led to take up this line. During the course of the year, however, I have received many applications from outsiders who have heard that mining instruction is to be added to the College curriculum, so that the demand for this class of education has arisen, and in the event of Engineering graduates not coming forward for mining instruction, it appears there are others eager to learn the work. It is with great satisfaction, therefore, that I am able to state that the College Laboratory, under Government sanction, will soon be in a position to undertake the instruction of students in this branch, a very considerable grant having been allotted for the purchase of the necessary apparatus.

Surveying.—The 2nd and 3rd-year classes of the Engineer Department went to Purulia again for field work under the charge of Mr. Heaton. The usual surveying and levelling operations were conducted, and maps of the adjacent country have been prepared. The 1st-year Engineering Department students were taught the usual course of surveying and levelling near the College, as were the various classes in the Apprentice Department who learn this subject.

Works visited.—The senior Engineering Department students visited the following works:—

(i) Jamalpore Workshops, (ii) Burn & Company's Workshops, (iii) Raniganj Pottery Works, (iv) Barakar Iron and Steel Works, (v) Head Works, Midnapore Canal, (vi) East Indian Railway Carriage and Wagon Works, Howrah, (vii) Burdwan Water-works, (viii) Serampore Water-works, (ix) Kidderpore Docks, (x) East Indian Railway Collieries, Giridih.

Testing apparatus.—This valuable addition to the equipment of an Engineering College still remains to be provided. With the meagre

appliances at our disposal a few tests have been made, but a properly equipped Laboratory is still much wanted. The Madras College has already received a large grant for this purpose, which I believe will be utilized for Government testing, as well as for instruction. If the necessary apparatus were supplied to this College it would enable Engineers in Bengal to purchase iron of known quality when emergent indents for work were placed in the local market. This would be a very valuable check on the quality of the material available, but a properly equipped Engineering Laboratory would be of even extended value, as it would help to exclude from the local market iron of an inferior quality. The importance of the exclusion of inferior metal has only to be understood to be appreciated. Engineers know how important it is to be certain of the quality of the metal they propose to use, and Government Engineers in this Province have no means of ascertaining this. Until proper apparatus is provided for testing the quality of imported iron inferior brands will be sent to India and Engineers will be afraid to use (except in unimportant structures) materials they know nothing about. It is well known that a very large percentage of the iron used locally would not come up to the Admiralty tests, and until this inferior metal can be excluded from the market, it will continue to be imported, and its use inadvertently in important structures might lead to serious mishap.

Models.—Since the 2nd and 3rd-year Engineer Department class rooms and the old drawing hall were erected, on the transfer of the classes to the new accommodation, more space has been available for models. The excessive over-crowding in the Chemical Laboratory has been relieved by the removal of the mineralogical and geological cases, and the old model room has also been cleared, so that it is now possible to move about among the models and explain them to the students. At present we are busy furnishing the extra accommodation at our disposal, so as to show off the specimens to better advantage. Among the models presented during the year, the chief are (i) a variety of sleepers in use on Indian Railways, presented by Mr. Finney, the special Lecturer for the year, (ii) Indian Midland Railway sleepers, presented by the Manager, Barakar Iron and Steel Works, (iii) Marchant's dredger, presented by Mr. Marchant, (iv) Morgan's feathering paddle-wheel, transferred from the Cuttack Workshops, has been practically made over again, as it was in a very delapidated condition when received, (v) a sectional model of the method of applying the vacuum brake to carriages, made in the College. In addition to this, various other models have been altered and improved, and the whole stock carefully looked after and cleaned.

Library.—The number of books purchased during the year was 66, and 14 were presented. The catalogue is still defective, and early attention to it is necessary. The majority of books has been entered on slips preparatory to cataloguing, but a special grant is required before a catalogue can be prepared. Mr. Macdonell has been good enough to help in this matter in his spare time; but before a complete catalogue can be prepared, Government must be asked to devote a small grant for this purpose.

Special Lectures.—Mr. Finney, Manager, Eastern Bengal State Railway, delivered a course of six lectures on Railway Construction

and Management. These lectures, with the accompanying diagrams, are in course of publication, and will soon be ready for sale.

Technical Schools.—The number of technical schools visited during the year were as follows:—Giridih, Bankura, Bihar, Dumraon, Burdwan, Comilla, and Pabna.

The affiliation of technical schools to the Sibpur College has advanced, and the following schools are now affiliated:—

Mymensingh, Burdwan, Rangpur, Pabna, Comilla and Bihar.

Within a measurable distance of time these schools will be able to act as feeders to this College, and in their present stage of existence, are teaching the elements of manual work in the various centres where they are located. The Bihar Industrial School sent up during the year 11 candidates for examinaton, 9 of whom passed and 6 were admitted into the third-year class of the Apprentice Department. Next year it is expected that at least two other affiliated schools will send up students for examination, and the movement is extending quite fast enough for the requirements of the Province. What we have to look to now is that the instruction is sound. At present the instruction of these schools devolves on me, as Principal of the Sibpur College, and I am endeavouring to do what I can in this direction; but as my present duties include, in addition to my professional duties, the management of a large residential College and the direct supervision of a Workshop, where nearly 350 students are being trained, the amount of time I can devote to inspection is necessarily small, and the strain on one man is very severe. I undertook the work with the sole object of keeping the instruction in the affiliated schools directly under the control of the Sibpur College, which is the final examining body, and which is the source from which the necessary equipment will issue, when these primary technical schools are able to advance their instruction. The organization of this vast scheme, which is now beginning to make its importance felt, will soon require special State aid. Hitherto it has cost the State nothing beyond the time I have been able to spare, but this cannot continue long, and it will shortly be necessary to appeal to Government for help. A movement of this kind, when once fairly started, must not be starved at the outset. It is much more complicated than the extension of ordinary primary education, as experts are required for its development and to keep instruction in the regular groove. At present I am trying to keep the movement going entirely by the aid of men trained at Sibpur. The great want now felt is an Assistant Inspector with European training, and a representation for the necessity for this appointment will shortly be submitted to Government.

With regard to the equipment of these schools, very little has been done during the year, as the students have been sufficiently well employed in helping to set our own shops in order and to equip our new laboratories. The only order now in hand is from the Elliott Artisan School, Comilla, which requires appliances of the value of Rs. 400, estimated according to our scale of charges. This apparatus, if purchased locally, would cost not less, and probably a good deal more than Rs. 2,000. A portion of this order is now ready, and the whole order will soon be despatched. This one order will give some insight into the proposed lines of working up these technical schools. The order is a small one

but at a cost of Rs. 2,000 is beyond the possibility of consideration in a school like that at Comilla. It is only a preparatory order, which will be supplemented by another when the school begins to advance after the receipt of the articles ordered.

There is nothing of special importance besides to record, except to mention that the original lines for advancing these schools have worked so well hitherto, that no change has had to be made in them. All that is now required is to leave the schools to work out their own development with the aid of careful and frequent inspection.

Workshops.—The year under review is the first year since the transfer of the practical training of the students from the Public Works Department to the Education Department. At the beginning of the year the new shops were ready, and the transfer was effected without any break of continuity in instruction, although, as will be found to be the case in all new shops, a great number of petty additions and alterations were required, which took up a good deal of the time of the instructors and students. Some shops were very incompletely equipped at the outset, and in the Iron Foundry, with the exception of the large cupola, which is expensive to work unless heavy castings are required, there was practically no other equipment. This necessitated the manufacture of a large number of moulding boxes, moulder's tools, a new cupola, and a variety of patterns, and in this respect we are now better equipped. The want of a saw bench to expedite the work in the carpenter's shop was much felt, but this has since been manufactured, and is now at work. The students have done fairly good work: they have helped to make two boats, and part of a third, all of different builds. A fair amount of furnishing work in connection with the equipment of the Chemical and Physical Laboratories has also been done by them. Machine manufacture has gone on, and although the advance in this direction is slower than I desired, there are various machines in course of construction which will shortly be finished, and whose value, if purchased in the market, is considerable. Three screw-cutting lathes were completed and erected in the year, the necessary shafting brackets for counter-shafts, &c., having been worked up or made up in the shops. On the whole, considering that the extra pressure of work on the students was a new departure, and that the instructors were busy over works connected with the extension and improvement of the College and Workshops, I consider the work done is satisfactory; but there is still room for improvement, both as regards the amount of work the students are able to do, and the instructive value of the work which should be given them to perform. The latter is being arranged for in various ways, and an experimental engine is being fitted up for the sole purpose of valve setting, which will be compulsory for all students of both departments and available at any time for this object. Experimental electric work was also conducted during the year, and dynamos and motors set to work. The transverse testing machine, purchased for a small sum from the East Indian Railway a few years ago, was erected in the shops, and though it is crude and of small power, we have been able to test cast-iron bars, in order to compare the outturn of the cupola with various mixtures of metal. In connection with the fittings of the new Laboratories a

certain amount of instruction has been given to the students in bending and fitting pipes for gas and water-supply, and in plumber's work. Pattern-making has also been introduced, and the patterns for several parts of the launch which it is proposed to build at the College, have been made from the drawings accompanying the lectures of Mr. Steele, who was appointed as a special Lecturer during the year.

Other works of minor importance were done, which it is impossible to enumerate in a report, such as alterations, additions, and repairs, but which are nevertheless of great instructional value; and on the whole I am satisfied that the first year that the practical training of the students was under the Educational Department is one that indicates a distinct advance on the old method, but I am more fully alive than ever that very great care and supervision is required to prevent its going back into the old lines. Students, as a rule, will not work if they can get the Instructors to work for them, and this rule holds good at Sibpur. My chief difficulty has been to try and overcome this tendency, and I fear that the present staff of Foremen Instructors is not sufficient to exercise the necessary supervision to see that each student performs a good day's work. It is almost impossible, without strict supervision, to control a large body of students in four different shops with varying knowledge, so as to get the best value out of their time. This year we are the only sufferers, but when we begin to equip affiliated technical schools, we shall require to make the most of the labour at our command, so as not to hamper the development of the scheme we have undertaken, and to secure this we shall require extra Foremen Instructors.

From a financial point of view the working is fairly satisfactory, as the value of the outturn is greater than the amount sanctioned by Government to meet the cost of practical training, excluding the pay of the Instructors, but including all petty establishment and working expenses. The approximate figures are given in another paragraph of this Report, and as there stated, the value of the work done has been estimated at a figure considerably lower than the price charged in the local market for manufactured articles. Most of the work done was required for the College and shops, and in this way we have been able to perform work for Government out of the practical training grant, without applying for extra funds, and at a cost considerably below that prevailing in the market. Many difficulties have had to be contended with, viz, insufficient clerical staff, want of touch with the local market where material had to be procured, and a sudden enlargement of the sphere of operation of the shops. The experience, however, gained during the year will be of great use in the future. Some of the more pressing requirements in the way of establishment have recently been sanctioned by Government, and every effort is being made to carry on the new development, without applying to Government for an increase in the staff of Foremen Instructors; but, as noticed above, this increase must come in time.

Workshop expenditure.—The cost of working the shops during the year amounted to Rs. 9,940. This included the cost of petty establishment, such as engine-drivers, firemen, greasers, cobblers, extra trained hands, and coolies; also the cost of fuel for engines and blacksmith's

shop; the value of iron, wood, belting, roping, shafting, and the other minor requisites required to carry on the work. The registered number of works undertaken during the year was 125, most of which were completed. The aggregate value of these works was about Rs. 9,000, this sum representing our estimate of the market value of the various works. In estimating this the prices fixed upon were, in most cases, considerably below the market value to allow for defects in finish. In addition to this, at the close of the year, there was a stock balance of over Rs. 1,200, exclusive of patterns for the moulding shop, the value of which it is difficult to estimate. The keeping of the accounts has given a good deal of trouble, as the system in vogue in the Civil Department is not adapted to Workshop expenditure. This question has formed the subject of various communications to Government, and the recently sanctioned orders of the Government of India with regard to powers of expenditure, especially in the case of goods of European manufacture, will be tried during the year. I am not at all sure, however, that they will meet the difficulty, and unnecessary correspondence will, I believe, continue, until the mode of keeping our Workshops Accounts are based on that in vogue in the Public Works Department. This part of the work in connection with the transfer of the practical training has given me more anxiety than I am able to express, and a further representation will have to be made to Government.

From the figures above given it will be seen that, from a financial point of view, the working was satisfactory. I do not think we could have procured from the local market the various articles which we made under a sum of Rs. 20,000, so that, roughly speaking, the shops have been self-supporting, including the pay of Instructors, which means that the cost of instruction has been practically nothing. This is satisfactory, and when the machines and tools we are making are erected and at work in the shops, our capacity for turning out work should be considerably increased. I do not see any necessity for deviating from our present class of work, and for many years to come we shall be completely absorbed in setting our own shops on a proper footing, and helping to equip technical schools. When demands come in in any numbers from these schools, it will strain us to our utmost capacity to cope with the orders, so that, for at last two years to come, we may consider we have our orders in hand.

Athletic Club.—The College Cricket XI had a most successful season, winning 11 and only losing 2 out of 16 Matches. They also won the Harrison Senior Cricket Challenge Shield, beating the Martinière in the final. This Shield has now been held an equal number of times by the Medical College and ourselves, and the honour of its permanent possession will be determined by a special Match next year.

The native students' Cricket XI won 3 and lost 4 out of 7 Matches, and were beaten in the final round of the Lansdowne Shield competition by Bishop's College.

In Association football the College team won 8 lost 4 and drew 2 out of 14 Matches, played and reached the semi-final in the Trades Cup competition, being then beaten by the Medical College.

The native students' team had a most successful season and had a good chance of winning the Elliot Cup, but owing to the College

breaking up for the Annual Vacation before the end of the competition, students living at a distance from Calcutta were unable to compete, and they had therefore to withdraw.

Instruction at the compulsory Gymnastic classes has been going on steadily, and it is proposed to institute an Annual competition.

Athletic Sports.—These were held on 11th March 1896, Mr. Macdonell kindly undertaking the preparations of the ground, which was finished a fortnight before the Sports, and it was gratifying to notice that many of the competitors attempted some sort of training. All events were keenly contested, and the results were above the average.

Volunteers.—The College Corps, which is No. 1 Engineer Corps attached to the East Indian Railway Volunteers is in a very efficient estate. All the students were efficient, and they attended as usual the Annual Camp of Exercise at Jamalpur for a week during December. A few of the best shots left during the year, but notwithstanding this, the Corps maintained its reputation in this respect.

J. S. SLATER,

Principal.

Analysis of Iron Ores, Rocks, and Fire clay made in the Chemical Laboratory.

No.	Name.	Locality.	SO_3.	SiO_2.	TiO_2.	P_2O_5.	Fe_2O_3.	Al_2O_3.	FeO.	MnO.	MgO.	CaO.	K_2O.	Na_2O.	H_2O.	Remarks.	Analyst.
1	Iron ore	Rasakund ...	(*a*) 0·13	...	...	...	46·42	31·26	...	...	0·03	0·108	...	...	...	.....	P. Brühl.
		Kharakpur Hills	(*b*)	1·19	2·04	...	0·31	0·67	...	Trace	Trace	0·042	...	...	17·82		
2	Iron ore	Kharakpur Hills	(*a*) 0·102	...	...	0·047	60·00	22·91	...	...	0·16	0·59	...	...	...	.....	W. P. Fleming and T. H. Berry.
			(*b*)	0·81	0·13	Trace	0·16	1·48	...	...	Trace	0·45	...	...	13·81		
3	Iron ore	Khobur	(*a*) 0·10	...	...	0·58	79·38	...	0·50	...	...	...	...	...	...	Partial analysis. Insoluble residue 5·83 per cent.	T. H. Berry.
		Nagode State ...	(*b*)	...	...	...	...	...	...	...	...	...	...	...	...		
4	Iron ore	Khobur ...	(*a*) 0·06	0·56	...	...	73·93	6·93	0·20	...	...	...	...	...	...	Partial analysis. Insoluble residue 16·32 per cent.	W. P. Fleming.
			(*b*)	...	...	...	...	...	...	...	...	...	...	...	11·71		
5	Iron ore	Satna ...	(*a*) 0·01	...	...	1·47	81·17	2·90	...	...	Trace	0·95	...	...	...		
			(*b*)	1·73	0·06	0·04	Trace	0·04	...	...	...	...	...	...	11·91	.....	W. P. Fleming.
6	Iron ore	Paramania ...	(*a*) 0·05	...	...	0·08	30·71	...	0·09	...	...	...	...	...	...	Partial analysis. Insoluble residue 57·50 per cent.	T. H. Berry.
		Nagode State ...	(*b*)	...	...	...	...	...	...	...	...	...	...	...	...		
7	Iron ore	Bhumara ...	(*a*) 0·02	..	...	0·67	84·34	0·64	0·26	...	...	...	...	...	11·50	.....	W. P. Fleming.
		Nagode State ...	(*b*)	2·47	...	...	Trace	0·38	...	...	...	...	...	...	...	.....	
8	Quartzite	Kharakpur Hills	...	98·58	...	...	0·75	0·78	...	...	...	...	...	...	0·08	.....	P. Brühl.
9	Garnet rock ...	Hazaribagh ...	...	37·13	...	...	23·28	5·11	...	0·59	0·30	30·13	...	...	3·02	.....	W. P. Fleming.
10	Rock of the appearance of porcelain Jasper.	Jabalpur district	...	87·70	...	...	2·08	6·98	...	0·01	...	...	...	...	2·58	.....	W. P. Fleming.
11	Fire-clay, black ...	Burn & Co.	...	68·32	2·24	Trace	Trace	21·94	...	...	Trace	0·64	0·19		...	Water and carbonaceous matter = 6·88 per cent.	W. P. Fleming.
12	Fire-clay		0·13	51·50	...	...	0·67	26·67	...	...	Trace	0·37	0·30		9·52	C = 9·83 %, H = 0·71 %, O + N = 0·16 %.	W. P. Fleming.
13	Fire-clay		0·11	63·07	0·80	Trace	Trace	22·18	...	...	Trace	0·40	0·22		7·42	Free from carbonaceous matter.	W. P. Fleming.
14	Fire-clay		0·20	61·59	1·67	Trace	Trace	25·66	...	...	Trace	0·36	0·36		8·57	C = 1·98 per cent ...	W. P. Fleming.
15	Fire-clay		0·17	69·49	...	Trace	...	23·53	...	...	0·11	0·25	0·47		7·41	.....	T. H. Berry.
16	Fire-clay		0·22	78·66	...	...	0·63	13·97	...	..	0·53	0·71	0·36		4·65	.....	T. H. Berry.

(*a*) = Portion soluble in HCl. (*b*) = Insoluble residue.

ANNUAL SPORTS.

ATHLETIC CLUB.

13th February 1896.

No. 1.—*300 yards Handicap* ...	... 1. V. Gardiner. 2. H. D. Bhaduri. 3. J. N. Ghose.
„ 2.—*High Jump* ...	... 1. B. N. Banerjee, 4 ft. 11 in. 2. S. E. Ansell, 4 ft. 10 in.
„ 3.—*100 yards Flat Race* ...	... 1. C. J. D'Cruze. 2. W. Fleming. 3. R. Young.
„ 4.—*Putting the Shot* ...	... 1. W. Lewty, 31 ft. 2. W. Fleming, 30 ft. 2 in.
„ 5.—*Quarter Mile Race* ...	... 1. W. Fleming. 2. R. Young. 3. V. Gardiner.
„ 6.—*Throwing the Cricket Ball*	... 1. C. J. D'Cruze, 97 yards. 2. L. Waterloo, 86 „
„ 7.—*Long Jump* ...	... 1. K. C. Dutt, 17 ft. 5½ in. 2. E. Linton, 17 ft. 3 in.
„ 8.—*Hurdle Race* ...	... 1. N. N. Mukerjee. 2. S. E. Ansell. 3. W. Fleming.
„ 9.—*Three-legged Race* ...	... 1. R. P. Bhaduri, A. T. Dutt. 2. S. C. Sanyal, B. L. Chatterjee.
„ 10.—*Sack Race* ...	... 1. K. C. Dutt. 2. H. C. Mukerjee.
„ 11.—*220 yards Flat Race* ...	... 1. C. D'Cruze. 2. W. Fleming. 3. H. D. Bhaduri.
„ 12.—*Tug-of-War* ...	... 1st & 2nd Pulls Oon by Engineers.
„ 13.—*Consolation Race* ...	... R. N. Choudhuri.
Best Athlete ...	... 1. W. Fleming, 15 points. 2. C. J. D'Cruze, 13 points.

C. A. P.—Reg. No. 980J—100—29-3-97.